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RESULTS OF CODLING MOTH INVESTIGATIONS, 1940

Part I

Work Conducted by State Agencies
and
Entomological Branch, Canadian
Department of Agriculture

Not for Publication

This pool of information on the results of codling moth research for the season of 1940 is the eighth of a series of summaries prepared annually by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, at the request of the Committee on the Codling Moth of the American Association of Economic Entomologists. This pool is prepared for the confidential information of workers who are interested in the codling moth problem. The material is not for publication and is therefore not available for quotation or other use without specific permission from the agency which has furnished it.

ARKANSAS

Dwight Isely, Arkansas Agricultural Experiment Station, Fayetteville

Codling moth control in northwestern Arkansas presented an unusually difficult problem in 1940. The most important factor probably was that a late spring frost destroyed a part of the crop, making the set of fruit very uneven in most orchards. Since late frosts had occurred for three years in succession, and there were other causes of discouragement many orchards were unsprayed or received only a part of the regular spraying schedule. This made the problem of control very difficult for growers whose orchards were adjacent to others which were neglected. The climatic conditions themselves were not unusually favorable to the codling moth. In contrast to the two previous seasons there were heavy rains in July and August.

Spraying experiments for codling moth control were carried on in a block of apples of the variety Golden Delicious. The trees chosen were relatively uniform in size, and as far as possible in set of fruit. The orchard in which this block was located had been in continuous bearing for the past 10 years. Even in 1936 and 1938, years of general frosts, when the crop in most orchards was destroyed, this orchard bore commercial crops. As a result the codling moth infestation was well established and evenly distributed.

Adjacent orchards also affected the problem. On the west was an unsprayed orchard of about four acres. Practically all of the fruit on this orchard dropped by September 1. On the south, within an eighth mile was a 60 acre orchard which received a calyx and three cover sprays. Migrations of moths from both these orchards increased the infestation.

Sprays for codling moth control were applied on the experimental trees according to the following schedule: Calyx spray, May 3; cover sprays for the first generation, May 13, May 28 and June 8; cover sprays for the second and following generations, July 3, July 24, August 7 and August 21.

Arsenate of lead was used in all the first five spray applications on all trees in the block and all these applications were made by the grower. One and one-half pounds to fifty gallons of spray mixture were used in the first three applications while two pounds to fifty gallons were used in the fourth and fifth applications.

The materials used to each fifty gallons in the various plots in the last three applications were as follows: Plot 1, arsenate of lead 1 1/2 pounds; plot 2, arsenate of lead 1 1/2 pounds plus 4 ounces of soybean flour; plot 3, phenothiazine 1 1/2 pounds; plot 4, 3/8 gallons nicotine in oil; plot 5, one pound of genicide with sticker; plot 6, arsenate of lead 1 1/2 pounds in two applications with the last application

omitted. The Department of Entomology assumed responsibility for making the last three applications.

Obviously these experiments were intended to show the relative value of materials which could be substituted to arsenate of lead in the summer spray applications. No substitutions early in the season were considered.

The harvest counts are shown in the accompanying table.

Summary showing percentage of wormy apples and extra worms in sprayed blocks. 1940

Plot Number	Percent of Wormy Apples	Ratio of extra Worms to 100 Apples
1	65.9	47.9
2	78.2	72.4
3	77.0	64.8
4	50.0	24.5
5	50.3	18.3
6	68.8	64.4

CALIFORNIA

A. D. Borden, University of California, Berkeley.

I. Seasonal abundance.

Following a comparatively cool summer, the attack of codling moth was very light. First brood population studies indicate the lowest moth activity since 1938.

III. Results of control experiments.

A. Control by insecticides

(1) Lead arsenate

A comprehensive experiment was set up to determine the more important factors involved in filling the calyx cups of Bartlett pears to prevent second brood larvae from entering through the calyx end of the fruit. The variables of pressure volume and type of discharge were considered and three values given to each variable. Lead arsenate without wetting agent

was used in the first part of the experiment consisting of 104 trees and lead-arsenate with three types of commercial wetting agents was employed in the second part of the experiment consisting of 52 trees.

Analyses of the calyx cups of 40 fruit per tree were made after each of the first two applications and observations made on the distribution of arsenical within the cup. Following two cover sprays the fruit of each four-tree plot was scored for worm injury in the calyx and the relation of each set of variables was determined.

Briefly summarizing the results, we found that increased volume low pressures, and the discharge from either the bamboo rod or short gun gave the maximum calyx deposits and worm control. Protein type spreaders gave the highest deposits and control in the spreader test.

(a) Though type and amount of arsenical deposits have greatly improved by the new commercial "invert" spreaders used in this State the past two seasons, much difficulty was experienced from the effect of "hard" water used in spraying. Much of the water used is pumped from wells and the total alkalinity may vary from 300 to 720 p.p.m. This has been shown to not only reduce deposits but also destroy film coverage.

(4) (a) Nicotine bentonite (Formula 155) with oil emulsion properly timed has proven quite effective in control of light second brood attacks on both late apples and pears.

(c) Randomized plots in late apple orchards of several varieties have shown Xanthone at a dosage of 3 pounds per 100 gallons to be as good as four pounds of lead arsenate when used against second brood attack. No injury occurred on Xanthone sprayed trees whereas arsenical sprayed trees showed the customary foliage injury in the near coastal areas. A two-pound dosage of Xanthone on Delicious apples in second brood control gave 89% clean fruit as compared with 96% clean fruit used standard lead arsenate. A specially prepared spreader (GX-spreader) was employed wherever Xanthone was used.

(d) Cryolite with oil emulsion continues to show promise for second brood control. "Hard" water seriously affects the deposit of this material.

B. Control by means other than spraying

Banding and light trap investigations temporarily discontinued.

IV. Spray residue

No serious difficulty with spray residue removal with up to 1-1/2% acid bath and occasional use of heat.

COLORADO

W. H. Newton, Bureau of Plant and Insect Control, Paonia.

(See attached statement)

CONNECTICUT

Philip Garman, Connecticut Agricultural Experiment Station, New Haven.

I. Seasonal condition and abundance of the insect during the 1940 season.

The codling moth for the first time in many years became a problem in at least one large commercial orchard in Connecticut. The infestation occurred on relatively high ground in a block of McIntosh. Several acres were so badly infested that the owner put in a thinning crew and removed all fruit. Inspection during early August showed that the infestation was near a packing shed filled with orchard crates, but alongside the shed was a pile of cord wood, mainly trunks of apple trees removed from the same orchard. The owner scraped, banded and dusted the trees on discovery of the fruit damage. The orchard crate situation will be taken care of in 1941.

It is evident that the codling moth increased over the entire orchard mentioned as well as other points in the State. For example, check trees in the Experiment Station Orchard at Mount Carmel showed 29 percent infested fruit, which is higher than usual.

The reasons for the general increase noted may be the high summer temperatures that have occurred in Connecticut during the last 10 years. However, in the severe outbreak, omission of early cover sprays had a direct influence as well as the possible concentration of moths by storage of crates and accumulation of cordwood with rough bark.

DELAWARE

L. A. Stearns, Delaware Agricultural Experiment Station, Newark.

I. Seasonal conditions and codling moth abundance during the 1940 season

In many Delaware orchards, there was a large codling moth population at the close of the 1939 season. It was expected, therefore, that the control problem would be rather acute in 1940. However, on account of the late spring, the first, spring-brood moths did not emerge until May 15. This is exactly one week later than the latest first emergence recorded during the ten preceding years. Although maximum emergence and 50 percent emergence occurred at about the usual date (May 22-23), the total emergence period covered but 33 days as compared with an average of 45 days for the years 1930 to 1939, inclusive.

This fact, and weather conditions, generally unfavorable for codling moth activity, facilitated control of the first brood. Injury by the first-brood worms was very light, especially in plantings which received the full number (4) of cover sprays recommended. For the State as a whole, the amount of stings toward the end of June was the least ever observed at that time for more than ten years. Second-brood attack, on the other hand, which was delayed until late August, was sufficiently severe so that a moderate to heavy infestation was experienced in certain sections by harvest time. The wintering population was, however, considerably less than in the fall of 1939.

II. Studies on codling moth biology or behavior

No special studies were made, aside from the periodical observations on seasonal development summarized above, which were necessary for the satisfactory conduct of spraying experiments.

III. Results of control experiments

In the report for 1938, data were presented showing that insoluble copper compounds, when combined with lead arsenate, were markedly inferior to Bordeaux-lead arsenate for codling moth control. It was pointed out that the lower efficiency of these products is undoubtedly due to the spray mixtures of such compounds, which are unable to produce the necessary high deposits of copper and arsenic on foliage and fruit.

Further results substantiating these data were presented in the 1939 report. Moreover, it had been found possible to increase the amount of clean fruit approximately 5 percent by the addition of a "spreader and sticker" in each of the applications in which insoluble coppers were used and by as much as 10 percent of the inclusion of summer oil in the same applications. In neither case, however, did the degree of control equal that obtained with lead arsenate-Bordeaux (3-3-5-100).

Continued experimental spraying of Jonathan and Stayman apples during the past season (1940) indicates that the three, lead arsenate-Bordeaux combinations (3-3-5-100, 3-2-4-100 and 3-1-3-100) were about equally effective for codling moth control. Of these, lead arsenate-Bordeaux (3-2-4-100) is probably the most satisfactory cover spray for apples under Delaware conditions, when considered from the standpoints of general insecticidal and fungicidal efficiency, arsenical correction and finish of the harvested fruit. This conclusion is based on the extensive work of the past three years.

IV. Spray residue

No further information available.

GEORGIA

C. H. Alden, Fruit Pest and Parasite Laboratory of the Georgia Department of Entomology, Cornelia.

1. Seasonal conditions and abundance of the insect during the 1940 season.

The preceding winter was exceptionally cold for this state. A low temperature of 3 degrees F. below zero was recorded in the northeast Georgia section and 15 degrees F. below zero in the northwest Georgia section in January of 1940. However, the cold was more or less continuous and did not result in a heavy mortality of the hibernating codling moth larvae as might have been expected. There was a large emergence of spring brood moths and more codling moths were caught daily in the bait pots than for the past several years. As a result of high codling moth population and a sub-normal crop, the apples were very wormy at harvest.

2. No studies made on codling moth biology or behavior.

3. Results of control experiments

(a) Control by insecticides

Lead arsenate - This was the standard lead arsenate summer oil and bordeaux mixture sprays and the results at harvest were as follows: 34.5% wormy, 31.1% stung, 29.3% extra stung and 43.5% sound.

Organic materials - This was the nicotine-bentonite-soy bean oil for the first three applications, starting with the first cover, followed by lead arsenate and bordeaux mixture for four more covers; the results at harvest on Delicious were as follows: 16.8% wormy, 8.9% stung, 4.5% extra stung, and 67.1% sound.

(b) Control by means other than spraying.

Biological control - About 25,000,000 Trichogramma minutum parasites were colonized in the commercial apple orchards in 1940. Over a ten year period, more than 37,000 codling moth eggs were collected in colonized orchards and of these about 65% were parasitized by T. minutum.

4. Spray residue

As a result of the raising of the tolerance standard, we had no trouble with the Georgia apples this year where they had been properly washed with the dilute hydrochloric acid bath.

ILLINOIS

W. P. Flint, Illinois Natural History Survey & Illinois Agricultural Experiment Station, Urbana.

I. There was a heavy winter carry-over of codling moth, with a high winter survival. The time of first brood appearance was about average. Conditions were somewhat unfavorable for egg-laying due to cool, wet weather, but better than in the spring of 1939. The insect continued to build up in abundance during a very dry, hot, late summer and fall, and late second and third brood worms were very numerous. Large numbers of codling moth larvae have gone into winter quarters in all orchard sections.

II. No special studies of codling moth behavior were made during this season. Light traps were run at Urbana, and bait traps at several points in the state. Some twenty orchardists cooperated in operating emergence cages. Special reports were also received from cooperating stations in Illinois and other states.

III. A. Codling moth experiments were carried on mainly in west-central Illinois, testing various combinations of nicotine and the feasibility of carrying on a nicotine schedule where the calyx and first cover were lead arsenate and all later sprays either tank-mixed or fixed nicotine. The results of these tests are given in the following table.

Plot No.	Materials Used per 100 Gallons	Percent of Fruit Entered	Stung
1	Modified B.L.155, 8 lbs., soy oil 1 pint in 1st brood, Superla 1/2 gal. in 2nd.	8.2	6.4
2	Modified B.L.155,7 lbs., soy oil 2nd cover, then Superla	6.6	3.3
3	B.L.155 Concentrate 3 lbs., bentonite 1 lb., soy oil 1 pint	9.1	8.1

4	Lead arsenate, weak Bordeaux, except last spray, Superla from 3rd cover on, B.L.155 with Superla used in last (Sept.) application	1.4	8.0
5	B.L.155 Concentrate 3 lbs., bentonite 1 lb., soy oil 1 pint for 2nd cover B.L.155 Concentrate 1 1/2 lbs., Superla 2 qts. later	10.9	5.2
6	Regular B.L.155 8 lbs., with soy oil 1 pt. for 2 cover and then Regular B.L.155 4 lbs., Superla 2 qts. later	6.2	6.4

In southwest central Illinois another year's tests were carried on with triple sprays. These were carried on in a large orchard (over 600 acres). While our plots were large, about ten acres in extent, they were probably not large enough to prevent the influence from the rest of the orchard. Under these conditions the triple spray failed to give satisfactory control. This is shown in the following table.

Plot No.	Description of Plot	Harvest Counts Percent of Fruit Entered	Stung
1	Standard Lead Arsenate	4.7	8.4
2	Triple Spray Lead Arsenate	9.2	11.2
3	Triple Spray Fixed Nicotine	26.6	2.6

Tests of the possibility of substituting some spreader or sticker in place of summer oil again gave good results as shown in the following table.

Plot No.	Treatment	Percent of Fruit on Tree Entered	Stung
1	Lead arsenate-Santomerse D	3.0	30.5
2	Lead arsenate-Weak Bordeaux-Summer oil	4.9	31.2

Very little injury to foliage occurred in 1940. Analyses of apples in our plots in growers' orchards showed that the present tolerances could be met in practically all cases on fall and winter apples where a calyx and two cover sprays of lead arsenate were applied. If a third cover was applied, the residue was likely to be above the tolerance. Here, as in all cases, the thoroughness with which the growers applied the sprays makes a great deal of difference in the amount of residue as well as in control.

(2) No tests were run with non-lead arsenicals.

(3) No tests were run with other inorganic materials.

(4) As above stated, tests with fixed nicotine were carried out. No other organic materials were tested.

B. (1) No experimental work was done with bands, though bands were used in a number of orchards.

(2) No tests were carried on with baits or lights.

(3) No special work along this line was done. Experimental orchards where checks have been made for the last three years and where no spraying has ever been done showed better than 60% codling moth infestation in all varieties, including Huntsmen, Grimes, Red Delicious, Jonathan.

IV. Spray residue (as above mentioned).

KANSAS

Ralph L. Parker and Paul G. Lamerson, Kansas Agricultural Experiment Station, Manhattan

INTRODUCTION 1/

The codling moth control program for 1940 was limited to lead arsenate combination sprays, due to the previous lack of successful control by use of non-lead and non-arsenical substitutes for lead arsenate. The tests were conducted in Doniphan County, adjacent to the Blair experimental orchard of the Northeast Kansas Experiment Fields, Kansas Agricultural Experiment Station. 2/

METHODS AND PROCEDURE

Three single tree replicates were used for each insecticide or combination of insecticides used. The replicates were selected at random in three rows in the experimental orchard. The total count of all dropped wormy and clean fruit beneath each of the test trees was begun July 9, and continued until September 4, when the preharvest drop began. Percentages dealing with codling moth injury were computed on the basis of 250 preharvest drops and 250 harvest time fruits per tree. The counted fruit was placed in the classifications wormy, stung and clean. Fruits both wormy and stung were scored as wormy and the sting disregarded. Multiple stings per individual fruit were disregarded for percentage records; the fruit was listed as stung.

1/ Contribution No. 496 from the Department of Entomology.

2/ The support of the experimental work reported in this paper came from the following projects: Hatch No. 13 and Northeast Kansas Experiment Fields No. 9. Mr. Donald Yost assisted with the work.

Lead arsenate at the rate of 4 pounds to 100 gallons of water was applied in the calyx spray to all test trees. Two lime sulphur sprays were applied to all trees in the test area. The use of stickers and spreaders was postponed until the third cover spray for the first brood due to possible foliage injury following the application of lime sulphur sprays. The use of summer oil emulsions in combination sprays was discontinued July 18. A late cover spray to protect fruit against injury caused by late hatched worms of the third generation was apolied September 7. This final cover spray was composed of lead arsenate 4 pounds to 100 gallons of water and was applied to all trees in the test area. A total of nine cover sprays was applied to the test trees during the season of 1940.

CLIMATIC CONDITIONS AND SPRAY INJURY TO FOLIAGE

The spray season of 1940 was characterized by moderate to severe spray injury to foliage of the Jonathan variety wherever adequate safeners for lead arsenate were not used. Even lead arsenate alone plus water gave severe arsenical burn to Jonathan foliage. Weak Bordeaux (3/4 pound copper sulfate plus 1 1/2 pounds of hydrated lime to 100 gallons of water) appeared to give adequate protection to foliage from arsenical burn. Zinc sulfate at the rate of 1/4 pound to 100 gallons of water gave nearly as good protection.

A drouth interval occurred between July 15 to August 7. Temperatures were above normal and ranging from 90° to 107°F. This drouth interval was followed by about 10 days of light showers. Rain fell on almost every day during this latter interval.

Foliage injury (arsenical burn) began to be apparent about August 17. From then until harvest, September 16 to 18, folage turned brown and fell from the trees in the test area. Defoliation was 33 1/3 to 50 percent complete by August 22.

This defoliation was apparent on all replicates included in the test areas except the lead arsenate zinc sulfate sprayed trees. While mild foliage arsenical burn was prevalent on trees in this plot most of the foliage remained on the trees. The comparison was outstanding between the lead arsenate-zinc sulfate block and the other treatments where no safener was used.

SEASONAL CONDITIONS AND CODLING MOTH ABUNDANCE FOR 1940

Overwintering brood. Moths began emerging May 13 but because of cool weather during the next two weeks catches of moths were erratic and straggling. Heavy catches were recorded between May 31 and June 7 with a peak of 305 moths in 10 traps occurring on June 3.

First brood. The first worm entries were noted June 4. A heavy hatch occurred between June 8 and 12. Many stings but few successful entries were noted during this period. After May 27 damage by the first brood was steady and continuous throughout its duration. More stings resulted from first-brood injury to fruit than has been noted for several seasons.

Second brood. Adults from the first brood became evident in the bait traps July 10. Moths began to be evident in the emergence cages July 14. By July 18 emergence was well under way and on July 24 a hatch of second-brood eggs was noted. Catches of moths began to diminish to some degree following heavy catches during the interval of July 22 to July 29. Insect damage to fruit during the drouth and high temperature interval of July 15 to August 7 was slight. Emergence of this brood extended from about July 10 to September 1. This is at best a mere estimate since the overlapping of broods occurred during the season of 1940. Damage to fruit by second-brood worms was the lightest experienced for several years. The bulk of the damage to Doniphan County fruit was caused by first-brood worms. The proportion of stung fruit was high due to the heavy carryover of worms during the season of 1939.

Third brood. Late fall injury to fruit during the season of 1940 was slight. Very cool weather during late August and early September kept the developmental progress of codling moth, during this interval, at a minimum. The value of the late spray applied September 7 to the codling moth test plots resulted in little additional worm control during the 1940 season. There was at best a small partial third brood of codling moth during the season of 1940 and the existence of this partial third brood could be questioned since there was much overlapping of broods during the season.

MATERIALS AND DOSAGES

The insecticide tests for control of codling moth in 1940 were restricted to the materials and dosages listed in Table I.

TABLE I

KINDS AND QUANTITIES OF INSECTICIDES USED PER 100 GALLONS OF SPRAY MIXTURE

Treatment
Lead arsenate 4 pounds
Lead arsenate 4 pounds plus zinc sulfate ($ZnSO_4$) 1/4 pound plus Orthol K Ready Mix oil 1 quart
Lead arsenate 4 pounds plus Orthol K Ready Mix oil 1 quart
Lead arsenate 4 pounds plus Spraysoy A 1/16 pound
Lead arsenate 4 pounds plus Spraysoy A 1/8 pound
Lead arsenate 4 pounds plus Spraysoy A 1/4 pound
Lead arsenate 4 pounds plus crude soybean flour 1/4 pound

A cooperative arrangement with the Doniphan County Farm Bureau enabled the entomological staff of the Northeast Kansas Experiment Fields to supply the growers with spray dates based on information obtained from a series of codling moth bait traps and emergence cages. Weather conditions and periods of oviposition were also considered in the selection of spray dates. Each cooperator was furnished a weekly summary of codling moth catches listed for each day of the preceding week. The codling moth spray schedule for the season of 1940 at the Blair experimental orchard was as follows: Calyx, May 10; first cover, May 23; second cover, June 5; third cover, June 13; fourth cover, June 24; fifth cover, July 12; sixth cover, July 18; seventh cover, July 31; eighth cover, August 19; and ninth cover, September 7.

At harvest time samples of apples from all plots were washed in a commercial washer by a packing and marketing company.

RESULTS

Data secured from the various insecticide tests for control of codling moth in the Blair experimental orchard at Blair, are recorded in the following tables.

TABLE II

SUMMARY OF SUMMER-DROPPED APPLE COUNTS JULY 9 AND 22, AUG. 5, 20 AND 29, 1940 AND PERCENTAGE OF WORMY, STUNG AND CLEAN

Treatment (per 100 gallons)	Total number apples per plot	Percent of fruit		
		Wormy	Stung	Clean
Lead arsenate 4 lbs., Orthol K Ready Mix oil 1 qt.	367	11.5	10.6	77.9
Lead arsenate 4 lbs. alone	296	4.7	19.6	75.7
Lead arsenate 4 lbs. Spraysoy A 4 oz.	591	7.4	17.5	75.1
Lead arsenate 4 lbs., Orthol K Ready Mix oil 1 qt., zinc sulfate 4 oz.	291	6.2	22.3	71.5
Lead arsenate 4 lbs., Spraysoy A 2 oz.	582	11.4	18.7	69.9
Lead arsenate 4 lbs., crude soybean flour 4 oz.	760	9.9	25.0	65.1
Lead arsenate 4 lbs., Spraysoy A 1 oz.	444	17.6	22.7	59.7

TABLE III

PREHARVEST DROPPED APPLE COUNTS (250 DROPPED APPLES PER TREE) SEPTEMBER 4 to 16, 1940, AND PERCENTAGE OF WORMY, STUNG AND CLEAN APPLES

Insecticide Treatment in 100 gallons of water	Total number apples per plot	Percent of fruit		
		Wormy	Stung	Clean
Lead Arsenate 4 lbs., Orthol K Ready Mix oil 1 qt.	750	1.33	10.53	88.14
Lead Arsenate 4 lbs.	750	1.07	13.20	85.13
Lead Arsenate 4 lbs., Spraysoy A 4 oz.	755	2.12	16.82	81.06
Lead Arsenate 4 lbs., Orthol K Ready Mix oil, zinc sulfate ($ZnSO_4$) 4 oz.	750	1.20	19.33	79.47
Lead Arsenate 4 lbs., Crude Soybean Flour 4 oz.	740	.94	22.03	77.03
Lead Arsenate 4 lbs., Spraysoy A 2 oz.	750	2.0	22.0	76.0
Lead Arsenate 4 lbs., Spraysoy A 1 oz.	750	2.67	24.53	72.80

TABLE IV

HARVEST COUNT (250 PICKED APPLES PER TREE) SEPTEMBER 16 to 18, 1940, AND PERCENTAGE OF WORMY, STUNG AND CLEAN APPLES

Insecticide Treatment in 100 gallons of water	Total number apples per plot	Percent of fruit		
		Wormy	Stung	Clean
Lead Arsenate 4 lbs., Orthol K Ready Mix oil 1 qt.	750	0.8	12.0	87.2
Lead Arsenate 4 lbs.	750	0.67	16.13	83.2
Lead Arsenate 4 lbs., Orthol K Ready Mix oil, zinc sulfate ($ZnSO_4$) 4 oz.	750	1.60	15.87	82.53
Lead Arsenate 4 lbs., Crude Soybean Flour 4 oz.	750	2.40	17.87	79.73
Lead Arsenate 4 lbs., Spraysoy A 4 oz.	750	1.20	19.87	78.93
Lead Arsenate 4 lbs., Spraysoy A 2 oz.	750	1.60	26.40	72.00
Lead Arsenate 4 lbs., Spraysoy A 1 oz.	750	2.93	25.07	72.00

TABLE V

COMPARATIVE PERCENTAGES OF CLEAN APPLES, 1940

PERCENTAGES OF CLEAN DROPPED APPLES FOR SUMMER, PREHARVEST AND PICKED FRUIT PER PLOT

TREATMENT (per 100 gallons)	July 9 to Aug. 29		Sept. 4 to 16		Sept. 16 to 18		Season total	
	Percent clean summer dropped fruit per plot.	Rank	Percent clean preharvest dropped fruit per plot	Rank	Percent clean picked fruit per plot	Rank	Percent clean season dropped and picked fruit per plot	Season Rank
Lead arsenate 4 lbs., Orthol K oil 1 qt.	77.9	1	88.14	1	87.2	1	85.8	1
Lead arsenate 4 lbs. alone	75.7	2	85.13	2	83.2	2	83.02	2
Lead arsenate 4 lbs., Spraysoy A 4 oz.	75.1	3	81.06	3	82.53	3	79.9	3
Lead arsenate 4 lbs., Orthol K oil 1 qt. zinc sulfate ($ZnSO_4$) 4 oz.	71.5	4	79.47	4	79.73	4	78.3	4
Lead arsenate 4 lbs., crude soybean flour 4 oz.	65.1	5	77.03	5	78.93	5	73.6	5
Lead arsenate 4 lbs., Spraysoy A 2 oz.	69.9	6	76.0	6	72.0	6	72.9	6
Lead arsenate 4 lbs., Spraysoy A 1 oz.	59.7	7	72.8	7	72.0	7	69.5	7

TABLE VI

RESIDUE ANALYSES OF LEAD ARSENATE SPRAY PLOTS
SAMPLES, 1940 (COMMERCIALLY WASHED)[3]

Insecticide Treatment in 100 gallons of water	Grains of arsenic (As_2O_3) per lb. of apples[4]			
	Sept. 5, 1940[5]		Sept. 16, 1940[6]	
	Unwashed	Washed	Unwashed	Washed
Lead arsenate 4 lbs. alone	0.20	0.04	0.265	0.036
Lead arsenate 4 lbs.+ Orthol K Ready Mix oil 1 qt.	0.230	0.039	0.213	0.054
Lead arsenate 4 lbs. + zinc sulfate 4 oz. + Orthol K Ready Mix oil 1 qt.	0.225	0.029	0.175	0.037
Lead arsenate 4 lbs. + Spraysoy A 1 oz.	0.24	0.053	0.240	0.033
Lead arsenate 4 lbs. + Spraysoy A 2 oz.	0.24	0.026	0.180	0.028
Lead arsenate 4 lbs. + Spraysoy A 4 oz.	0.175	0.035	0.130	0.034
Lead arsenate 4 lbs. + crude soybean flour 4 oz.	0.207	0.037	0.205	0.034

3. Residue analyses were made by Dr. B. L. Smits, Department of Chemistry, Kansas State College.

4. The arsenic tolerance allowed by the Federal Security Agency of the United States Department of Agriculture for 1940 is 0.025 grains of arsenic per pound of fruit or vegetable.

5. Eighth and last cover spray applied by growers on Aug. 19. These samples were taken just before the extra experimental spray was applied on Sept. 7.

6. Additional experimental control program spray applied Sept. 7, to control partial third brood worms. These samples were taken at harvest time.

GENERAL OBSERVATIONS

The growing season of 1940 was one of the most favorable for the production of apples during the past 5 years. Except for a brief interval during midsummer and again during the late fall rainfall was well distributed. Early fall temperatures were cool and the fruit colored well.

DISCUSSION

1. Lead arsenate 4 pounds plus summer oil emulsion 1 quart to 100 gallons of water gave the best codling moth control during the season of 1940. Better control can be expected from the above dosage in years with a fair distribution of rainfall than with lead arsenate alone.

2. Lead arsenate alone gave second best control of all combinations tested. Possibly the reason for lead arsenate alone ranking so high in effective control during the 1940 season was due to the fact most of the rainfall came in easy showers during the growing season.

3. Lead arsenate 4 pounds plus Spraysoy A 4 ounces to 100 gallons of water gave third best control of all combinations tested.

4. Lead arsenate 4 pounds plus zinc sulfate ($ZnSO_4$) - 4 ounces, plus summer oil emulsion 1 quart to 100 gallons of water ranked fourth of all combinations tested. This was the only test plot that held most of its foliage until after picking time. Heavy foliage loss due to arsenical burn was characteristic of all other lead arsenate combination spray test plots studied. Even lead arsenate alone 4 pounds to 100 gallons of water caused severe foliage burn on all replicates.

5. Effective control of codling moth fell off rapidly when less than 2 ounces of Spraysoy A was used for each 100 gallons of spray.

6. The foliage injury of 1940 appears to indicate that the use of heavy dosages of lead arsenate on Jonathan foliage must be used with adequate safeners.

7. Bordeaux mixture (3/4 pound copper sulfate plus 1 1/2 pounds hydrated lime to 100 gallons of water) appeared to give adequate protection to Jonathan foliage from lead arsenate burn. Zinc sulfate at the rate of 4 ounces to 100 gallons of water also gave some protection to foliage from arsenical burn.

8. Codling moth damage to fruit was outstanding in the number of first-brood stings to fruit that resulted from the heavy carryover of worms from the season of 1939. These stings resulting from first-brood worms were so severe that they were apparent at harvest time. Damage resulting in off grade fruit resulting from stings was high during the season of 1940.

9. It would appear that better provision for effective cleaning of fruit by washing methods should be followed if the heavy applications of arsenical spray so necessary for controlling codling moth in Northeastern Kansas become standard practice by most growers. Commercial washing of

samples from the spray test plots failed to bring the fruit within the arsenical tolerance. Reasons for above tolerance readings can be listed as follows:

a. Heavy foliage loss to trees in the test plot areas during late August resulted in failure of the fruit to size up well.

b. Heavy deposits of lead arsenate resulting from the heavy spray program (9 cover sprays).

c. The application of one of these cover sprays as late as September 7.

d. The fruit washing machine used had no facilities for heating the acid wash.

e. The volume percentage of acid present in the wash was low, about 1 percent, and not the standard of 3 percent which is recommended.

SUMMARY

Lead arsenate 4 pounds plus summer oil emulsion 1 quart to 100 gallons of water gave the best codling moth control for the season of 1940; lead arsenate alone 4 pounds placed second; and lead arsenate 4 pounds plus spraysoy A 4 ounces to 100 gallons of water third.

The severe foliage injury of 1940 appears to indicate that adequate safeners should be used with heavy dosages of lead arsenate. Bordeaux mixture prevented excessive foliage injury as did zinc sulfate.

When heavy dosages of lead arsenate are used, an effective washing method should be carried out to reduce the residue to that below the United States Department of Agriculture tolerance.

KENTUCKY

W. A. Price, Kentucky Agricultural Experiment Station, Lexington.

In spite of the rather severe winter of 1939-1940, there was a heavy carry-over of codling moth in the state. At Lexington, it was estimated that the winter mortality was around 20 percent. First brood codling moth flight was unusually heavy thruout much of the State but most growers obtained fairly good control of first and second brood worms. In many orchards these results were largely nullified by third brood worms in September.

The late season during the first part of 1940 delayed codling moth pupation and emergence. At Lexington, the first pupa was found April 24. Moth emergence began May 6 at Paducah and May 7 at Princeton, according to Mr. Armstrong's records. The first moth emergence at Lexington was found May 19. At Lexington, first brood flight was prolonged extending from May 19 thru June. First generation moths began emerging June 25 at Paducah and on July 14 at Lexington.

No detailed control experiments were run. At Lexington, in the old station orchard, a lead arsenate schedule consisting of five first brood cover sprays and three second brood cover sprays resulted in considerable foliage injury and reduction in fruit size. On Red Delicious this schedule produced 61.8 percent clean fruit. In the new, station orchard, a fixed nicotine-summer oil schedule, consisting of five first brood cover sprays, and five later cover sprays resulted in 80 percent clean fruit on Delicious and 94 percent clean fruit on Winesap with no foliage injury.

MASSACHUSETTS

A. I. Bourne, Massachusetts Agricultural Experiment Station, Amherst.

I. April: one of coldest periods for that month on record at this Station. Station. Heaviest snowfall on April 21-22 (4 inches) on record for such a late date.
May: rainy and cold.
Seasonal development of orchard trees a week to 10 days later than normal, and continued cold weather made progress of insect development slow. On the whole, codling moth development kept pace with the progress of trees.

Over State as a whole, codling moth appeared to be on the increase due in part to favorable weather conditions. Growers, however, cannot be excused entirely for this condition; have been careless in cleaning up conditions in orchard:
Prop poles - prunings - old boxes, broken picking baskets, and other debris.
Same true around packing sheds:
Orchard boxes - pads - etc., containing many cocoons often allowed to remain undisturbed in and around sheds.

II. Bait pail records showed moth emergence from sheds and packing houses later than in orchard. Therefore blocks around such points have often suffered severely and required special schedule.

III. Black Leaf 155: on McIntosh, Rhode Island Greening, Northern Spy.
McIntosh block:
Exposed on one side to orchard heavily infested with codling moth; on other side to young block which received only lead arsenate schedule.

Northern Spies: 1 solid block
1 block, Spies and Rhode Island Greening alternated.

Inspection of fruit at harvest showed:
McIntosh: 2 applications Black Leaf 155.
Trees exposed to badly infested orchard: 2.18% fruit showing "stings"
Trees in center of block: 1.09% " " "

1 application Black Leaf 155.
Trees in center of block: 3.07% fruit showing "stings"

Block receiving Lead Arsenate Schedue only: 11.02% fruit " "

****

Northern Spy: Solid block - 2 applications of Black Leaf 155
Marginal trees (exposed as above): 4.7% fruit showing "stings"
Trees in center of block: 2.6% " " "

R. I. Greening & Northern Spy alternated - 2 appli. B. L. 155
Northern Spy : 1.5% fruit showing "stings"
Rhode Island Greening : 1.4% " " "

IV. Samples of McIntosh from the experimental orchards showed both lead and arsenic residues to be well below the present tolerance requirements.

Fruit from plots receiving the standard schedule of lead arsenate and liquid lime-sulfur in pre-blossom and calyx applications and lead arsenate with wettable sulfur in 4 cover sprays showed:

As_2O_3 = .006 grain per pound and PbO = .011 grain per pound.

Similar analyses of fruit from plots receiving lead arsenate with wettable sulfur throughout the season showed:

As_2O_3 = .004 grain per pound and PbO = .011 grain per pound.

Lead arsenate was used at 4 pounds in Calyx, 1st and 2d Cover Sprays;
at 3 pounds in Preblossom and 3d Cover Sprays;
at 2 pounds in 4th Cover Spray.

2d Cover was applied June 28; 3d Cover, July 9; 4th Cover, July 22.

Fruit was harvested September 27 and 28.

Rainfall during August and September was very slight; less than one-half of the normal. Even under those conditions the margin of safety was such that artificial removal of residue would not be necessary.

MICHIGAN

Ray Hutson, Michigan Agricultural Experiment Station, East Lansing.

I. The 1940 season was characterized in Michigan by a late wet spring with consequently irregular emergence of first brood. Following this, severity of infestation, influenced by heavy rains interspersed with hot spells, was intermittent and hard to meet, but losses were average except in a few orchards.

II. No studies on biology or behavior.

III. A. Results of Control Experiments.

Two control set-ups were used:

The first consisted of observations on twenty three well sprayed orchards showing good control of codling moth and consisting of McIntosh, Northern Spy, Baldwin, and Steele's Red to determine the result of spraying dates on residue.

Analyses from these orchards showed:

1. Five cases of lead residue beyond the 1940 tolerances.

2. One case of arsenical residue beyond the 1940 tolerance.

3. All cases of excessive residue resulted from sprays applied after August 1st.

An experimental heavily-infested, lightly-bearing set-up of McIntosh was employed in which the trees were divided into three tree plots and each treatment applied to three randomized plots with randomized check plots receiving only calyx and first cover of lead arsenate for codling moth control. Spray treatments indicated began with the second cover; second and third covers at 7 day interval from preceding spray, all others at 10 day interval. Treatments and results are apparent from the following tabulations.

SPRAY TREATMENTS MCINTOSH-1940. - SEVEN APPLICATIONS.

TREATMENT	SPRAY MATERIALS
1	4 lbs. B.L. 155, 2 qts. oil.
2	3 lbs. lead arsenate.
3	4 lbs. Mod. 155, 2 qts. oil.
4	1-1/2 lbs. B.L. 155 (14%) 2 qts. oil.
5	3 lbs. B.L. 155.
6	3 lbs. B. L. 155 (14%), 1 lb. bentonite First Brood 3 lbs. B. L. 155 (14%) Second Brood

SYNOPSIS CONTROL COUNTS CODLING MOTH ON MCINTOSH-1940.

Treatment	Total Apples	Stung Apples	% Stung	Wormy	% Wormy	Clean	% Clean
1	5752	1696	29.4	1170	18.9	2886	51.7
2	8255	5105	61.8	1445	17.6	1705	20.6
3	6972	2752	39.4	639	9.2	3581	51.4
4	8259	3283	39.7	810	8.7	4266	51.6
5	7238	3862	53.3	1312	19.6	2064	27.1
6	5199	2923	56.2	1094	21.1	1182	22.7
Check-Mac.	1801	415	23.	1223	67.3	163	9.7

B. No formal experimentation on means other than spraying.

IV. Spray Residue.

As indicated under control by insecticides, indications are that Michigan growers can meet present tolerances by refraining from late season spraying with arsenicals. Growers seem to be pretty well satisfied with the possibilities offered by the possibility of using arsenicals with fungicides during the early part of the season and taking care of late hatching larvae by fixed nicotines.

MISSOURI

L. Haseman, Missouri Agricultural Experiment Station, Columbia.

I. Seasonal conditions and abundance of the insect during the 1940 season.

Throughout Missouri, weather conditions slowed down and extended the period of first brood moth emergence in the spring and this drawing out of the broods was also reflected in case of the second and third broods. Until fall, while the drawn-out broods made it difficult to time the applications to best advantage, worm control generally was good. However, with the open fall, with no real killing frosts over most of the State until the November freeze, we had an exceptionally heavy buildup of third brood worms and consequently much late worminess of fruit on the winter varieties.

In southwest Missouri lead arsenate burned more than usual, according to W. W. Smith who has charge of experimental work there.

II. Studies on codling moth biology or behavior.

Behavior and biological studies on the codling moth were largely restricted to the annual study of moth and worm development of the three broods.

III. Results of control experiments.

(a) In 1940, the experimental setup was similar to previous years, with commercial orchard experimental plats at Elsberry, Cape Girardeau, Mountain Grove, Marionville, and St. Joseph, Missouri. Spray dilutions combined with a large series of spray mixtures and combinations of mixtures were included in the experiments.

(b) As mentioned above, the emergence of moths of the different broods was drawn out badly, thus requiring careful timing of applications, but the worst setback

to final results was due to the favorable conditions for the development of an unusually heavy third brood of worms in the fall.

(c) Control results included in the accompanying tables.

(d) No unusual spray injury appeared on foliage and fruit in 1940.

(e) No analyses for spray residue were made.

A. Control by insecticides.
Given in accompany tables.

B. Control by means other than spraying.
As in 1939, banding and bait traps were used primarily in following the development of moths and larvae of the different broods.

IV. Spray residue.

No spray residue analyses were made this year, but most of our commercial growers used their washing equipment or wiping equipment with that portion of their crop moved interstate. The tolerance changes have been very favorably received by Missouri growers, since they have found that it has materially reduced their spray residue removal problems.

PIONEER ORCHARDS, CAPE GIRARDEAU, MISSOURI

Variety: Jonathan

Plat	Treatment (Quantities are for 100 gallons)	% Clean	% Stung	% Wormy
1	3 lbs. Phenothiazine (DuPont's 1939 'make') in all covers.	72.4	2.2	25.7
2	8 lbs. Black Leaf 155 in 1st cover. 6 lbs. Black Leaf 155 plus 2 qts. summer oil in 2nd, 3rd, & 5th covers. 4 lbs. Black Leaf 155 plus 2 qts. summer oil in 4th & 6th covers.	85.9	2.6	11.4
3	3 lbs. Lead Arsenate, 5 lbs. hydrated lime, in 1st, 2nd, 3rd, & 5th covers. 2 lbs. Lead Arsenate, 3 lbs. Lime, in 4th & 6th covers.	88.1	3.5	8.5
4	Same as Plat 3, except 3 qts. of summer oil were added in the 2nd, 3rd, & 5th covers.	94.9	1.2	4.6
5	3 lbs. Lead Arsenate, 5 lbs. Lime, in 1st cover. 3 qts. Nicosol plus 1 lb. powder in 2nd, & 6th covers. 2 qts. Nicosol plus 1 lb. powder in 3rd, 4th, & 5th covers.	89.4	2.5	8.0
6	Same as Plat 3.	86.2	4.2	9.9
7	3 lbs. Phenothiazine (DuPont's 1940 'make') in all covers.	69.2	1.9	28.7

Spray Dates: Calyx - April 27
1st cover - May 13
2nd cover - May 24
3rd cover - June 8
4th cover - June 20
5th cover - July 6
6th cover - July 26

RINGHAUSEN ORCHARD, ELSBERRY, MISSOURI

Variety: Jonathan

Plat	Treatment (Quantities are for 100 gallons)	% Clean	% Stung	% Wormy
1	2 lbs. Lead Arsenate, 1 gal. summer oil, in 1st cover. 2 lbs. Lead Arsenate in 2nd, 3rd, 4th, & 6th covers. 3 lbs. Lead Arsenate in 5th cover.	24.4	66.8	27.7
2	Same as Plat 1 in 1st cover. 3 lbs. Phenothiazine plus 1 pt. DuPont sticker, in 2nd, 3rd, 4th, 5th, and 6th covers.	24.2	52.0	40.2
3	Same as Plat 1 in 1st cover. 8 lbs. Black Leaf 155 in 2nd, 3rd, 4th, 5th and 6th covers.	24.7	57.8	44.4
4	Same as Plat 1 in 1st cover. 2 lbs. Lead Arsenate plus 4 oz. Santomerse "D" in 2nd, 3rd, 4th, and 6th covers. 3 lbs. Lead Arsenate plus 4 oz. Santomerse "D" in 5th.	33.4	30.0	24.1
5	Same as Plat 1 in 1st cover. 2 lbs. Lead Arsenate plus 1 gal. summer oil in 2nd, 3rd, 4th and 6th covers. 3 lbs. Lead Arsenate plus 1 gal. summer oil in 5th cover.	46.6	46.9	15.4
6	Same as Plat 1 in 1st cover. 2 lbs. Lead Arsenate plus 1 gal. summer oil plus 10 lbs. brown sugar in 2nd, 3rd, 4th, and 6th covers. 3 lbs. Lead Arsenate, 1 gal. summer oil, 10 lbs. brown sugar, in 5th cover.	66.0	31.7	6.2
7	Same as Plat 1.	31.2	63.8	20.1
8	Same as Plat 1 in 1st cover. 3 lbs. regular derris in 2nd, 3rd, 4th, 5th, and 6th covers.	28.5	54.5	42.5
9	Same as Plat 1 in 1st cover. 3 lbs. stabilized derris in 2nd, 3rd, 4th, 5th, & 6th covers.	27.8	55.0	33.6

Spray Dates:
1st cover - May 20
2nd cover - June 1
3rd cover - June 13
4th cover - July 4
5th cover - July 27
6th cover - Aug. 14

KENMOOR ORCHARDS, ST. JOSEPH, MISSOURI

Plat	Treatment (Quantities are for 100 gallons)	% Clean	% Stung	% Wormy
1	2 1/3 lbs. Lead Arsenate, 4 1/6 lbs. Dry Lime Sulfur, in 1st cover. 3 lbs. Lead Arsenate, 1 1/2 lbs. hydrated lime in 2nd cover. 4 lbs. Lead Arsenate, 2 lbs. lime, 1/4 lb. copper sulphate, in 3rd cover. 4 lbs. Lead Arsenate in 4th & 5th covers. 3 lbs. Lead Arsenate in 6th & 7th covers.	58.5	19.4	22.8
2	Same as Plat 1, except 1 pt. Nicotine Sulphate and 3 lbs. Lime added to 2nd cover for moth kill, and 1 pt. Nicotine Sulphate and 1/2% Superla to 3rd cover with Bordeaux omitted.	46.6	19.1	33.0
3	Same as Plat 1 in 1st cover. 2 pts. Nicotine Sulphate, 5 lbs. Bentonite, 1 qt. soybean oil, in 2nd & 3rd covers. 1 pt. Nic. Sul., 5 lbs. Bent., 1 qt. soybean oil, in 4th cover. 6 lbs. Black Leaf 155, 1/2 gal. Superla, in 5th cover. 4 lbs. B.L.155, 1 qt. Superla, in 6th cover. 6 lbs. B.L.155, 1/4 gal. Superla, in 7th cover.	40.7	8.6	44.3
4	Same as Plat 1 in 1st cover. 6 lbs. B.L.155, 1 pt. Nic. Sul., 1/2 gal. Superla, in 2nd & 3rd covers. 6 lbs. B.L.155, 1/2 gal. Superla, in 4th & 5th covers. 4 lbs. B.L.155, 1/4 gal. Superla, in 6th cover. 6 lbs. B.L.155, 1/4 gal. Superla, in 7th cover.	45.6	8.4	41.6
5	Same as Plat 1 in 1st cover. 3 lbs. B.L.155 Concentrate, 1/2 gal. Superla, in 2nd, 3rd, & 4th covers. 2 lbs. B.L.155 Concentrate and 1/4 gal. Superla, in 5th, 6th, & 7th covers.	53.9	5.94	32.2
6	Same as Plat 1 in 1st cover. 4 lbs. B.L.155, 2 lbs. Bent., 1 pt. soybean oil, in 2nd cover. 3 lbs. B.L.155 Concentrate, 2 lbs. Bent., 1 pt. soybean oil, in 3rd & 4th covers. 2 lbs. B.L.155 Concentrate, 1/2 gal. Superla, in 5th cover. 2 lbs. B.L.155 Concentrate, 1/4 gal. Superla, in 6th & 7th covers.	55.0	8.26	32.0
7	Same as Plat 2	63.8	16.4	18.76
8	Same as Plat 1	64.26	19.2	16.46

Spray Dates:

Calyx - May 8
1st cover - May 22
2nd cover - June 1
3rd cover - June 8
4th cover - June 21
5th cover - July 19
6th cover - Aug. 1
7th cover - Aug. 20

SENEFF ORCHARD, MARIONVILLE, MISSOURI

Variety: King David

Plat	Treatment (Quantities are for 100 gallons)	% Clean	% Stung	% Wormy
1	2 lbs. Lead Arsenate, 2 lbs. Lime, 2 lbs. Mulsoid Sulfur, 1 gal. Lime Sulfur, in 1st cover. 8 lbs. Black Leaf 155, 4 lbs. Mulsoid Sulfur, in 2nd cover. 6 lbs. B.L.155, 1/2 gal. Superla, in 3rd & 6th covers. 4 lbs. B.L.155, 1/2 gal. Superla, in 4th & 7th covers. 4 lbs. B.L.155, 3/4 gal. Superla, in 5th cover.	33.0	21.9	57.9
2	Same as Plat 1 in 1st cover. 3 lbs. Lead Arsenate, 3 lbs. Lime, and Bordeaux in 2nd cover. 3 lbs. Lead Arsenate, 3 lbs. Lime, in 3rd & 6th covers. 2 lbs. Lead Arsenate, 2 lbs. Lime, in 4th, 5th, & 7th covers.	15.7	59.1	63.2
3	Same as Plat 2, except that 1/4 lb. soybean flour was added to each cover spray except the first one.	30.2	47.4	46.4
4	Same as Plat 1 in 1st cover. 3 lbs. Black Leaf 155 Concentrate, 4 lbs. S-W Mulsoid Sulfur, in 2nd cover. 2 lbs. B.L.155 Con., 1/2 gal. Superla, in 3rd, 6th, & 7th covers. 1 1/2 lbs. B.L.155 Con., 1/2 gal. Superla, in 4th cover. 1 1/2 lbs. B.L.155, 3/4 gal. Superla, in 5th cover.	52.9	16.4	37.3
5	Same as Plat 2 in first four covers. 2 lbs. Genecide, 1 lb. sodium oleate soap, 4 1/2 ozs. monohydrated zinc sulfate, in 5th, 6th, and 7th covers.	15.0	39.7	76.6
6	Same treatment as for Plat 2, except that 1/2 gal. Superla was added to the 3rd, 4th, and 6th covers, and 3/4 gal. Superla to the 5th cover. Bordeaux was used instead of Mulsoid sulfur in the 2nd cover.	21.0	44.3	60.2
7	Same treatment as for Plat 6, except that Shell summer oil (Medol) was used instead of Superla summer oil.	18.3	50.8	65.2

Spray Dates:

Calyx	- May 2	4th cover	- June 13
1st cover	- May 13	5th cover	- July 2
2nd cover	- May 23	6th cover	- July 23
3rd cover	- June 3	7th cover	- Aug. 14

STATE FRUIT EXPERIMENT STATION, MOUNTAIN GROVE, MISSOURI

Variety: Champion

Plat	Treatment (Quantities are for 100 gallons)	% Clean	% Stung	% Wormy
1	2 lbs. Lead Arsenate, 2 lbs. Lime, in 1st cover. 8 lbs. Black Leaf 155, 1/2 gal. Superla, in 2nd cover. 6 lbs. B.L.155, 1/2 gal. Superla, in 3rd, 4th & 5th covers. 4 lbs. B.L.155, 1/2 gal. Superla, in 6th, 7th, & 8th covers.	60.2	16.0	23.8
2	Same as Plat 1 in 1st cover. 3 lbs. Lead Arsenate, 3 lbs. Lime, in 2nd, 3rd, 5th, and 7th covers. 2 lbs. Lead Arsenate, 2 lbs. Lime in 4th, 6th, and 8th covers.	42.4	45.8	12.4
3	Same as Plat 1 in 1st cover. Same as Plat 2 except that 1/2 gal. Superla was added to the 2nd, 3rd, 5th, and 6th cover sprays.	65.0	28.2	9.4
4	Same as Plat 2, except that 1/4 lb. tar soap flakes and 1/2 gal. kerosene were added to the 2nd, 3rd, 5th, and 6th covers.	58.0	38.7	4.5
5	Same as Plat 1 in 1st cover. 1/2 gal. Nicosol oil, 1 lb. Nicosol powder, in 2nd, 4th, 5th, 7th, & 8th covers. 3/4 gal. Nicosol oil, 1 1/4 lbs. Nicosol powder, in 3rd & 6th covers.	56.8	13.0	33.3
6	3 lbs. Lead Arsenate, 3 lbs. Lime, in 1st & 2nd covers. 2 1/2 lbs. Lead Ars., 2 1/2 lbs. Lime, in 3rd cover. 4-4-100 Bordeaux, 3 lbs. Lead Ars. 1 pt. Black Leaf 40, 3/4 gal. Superla in 4th cover. 1 pt. GN-67* in 5th, 6th, & 7th.	31.9	51.7	40.0
	(Variety: Golden Delicious)			
1A	First four cover sprays same as in Plat 6, except that 2 gal. liquid lime sulfur was added to the 1st & 2nd covers. 2 lbs. Genecide, 1 lb. sodium oleate soap, 4 1/2 ozs. zinc sulfate, in 5th, 6th & 7th covers.	58.5	24.7	16.8
	(Variety: Golden Delicious)			
2A	First four cover sprays same as in Plat 6. 2 1/2 lbs. Lead Arsenate and 2 1/2 lbs. Lime in 5th, 6th, & 7th covers.	62.1	15.2	21.5

(*This material was used mistakenly at half strength.)

Spray Dates:

Calyx - May 6
1st cover - May 17
2nd cover - May 27
3rd cover - June 5
4th cover - June 20
5th cover - July 8
6th cover - July 24
7th cover - Aug. 7
8th cover - Aug. 22

C. E. HITZ ORCHARD, FORTESCUE, MO.

Bloom Removal for Codling Moth Control in 1939.

Counts were made in October 1940 on larvae on tree trunks. The trunks were scraped and the number of larvae per tree recorded.

Results follow:

Variety	Treatment	No. Trees checked	Total Larvae	Av. Larvae Per Tree	Distance from Untreated Rows
Ben Davis	None	5	267	53.4	None
" "	Bloom removed in 1939	5	102	20.4	1-3 rows
" "	Bloom removed in 1939	5	63	12.2	10 rows

Counts made on larvae on tree trunks in March, 1940, showed the following results:

Variety	Treatment	No. Trees Checked	Larvae Dead	Larvae Alive	Date
Ingram	None	4	337	112	March 18
"	Bloom removed in 1939	10	7	1	" 20
"	None	10	290	97	" 27

NEW JERSEY

Byrley F. Driggers, New Jersey Agricultural Experiment Station, New Brunswick.

I. Seasonal conditions and codling moth abundance.

In southern New Jersey a heavy carry-over of larvae from the extremely severe codling moth season of 1939 occurred. In central and northern New Jersey the carry-over of larvae was light due to the activity of predators, particularly birds. Cool weather unfavorable for codling moth development occurred during June resulting in a much easier control of first brood larvae in central and southern New Jersey than was the case in 1939. Hot, dry weather occurring the last half of July and the first half of August resulted in what began to be a severe second brood attack in orchards where first brood had not been controlled satisfactorily. However, the last half of August turned cool and wet with the result that there was an early "shut off" of second brood pupation. The net result of a cool first brood season plus an early "shut off" in August was a relatively easy year for the control of codling moth in New Jersey.

II. Studies on codling moth biology and behavior.

No work carried on.

III. Results of control experiments.

A. Control by insecticides.

(1) Lead arsenate. A series of arsenical corrective plots were run in 1940 testing several correctives which had shown promise elsewhere. The correctives were used in a summer oil-lead arsenate schedule on the Rome and Stayman varieties in two different orchards in the state. The various plot treatments were begun at the third cover spray. Previous to that spray all the plots received a petal fall spray of wettable sulfur, lime and lead arsenate followed by a 7-day spray of lead arsenate, lime and sticker, followed by a 14-day spray of lead arsenate, lime, a commercial copper compound and sticker. Beginning with the third cover spray the check plot received the regular New Jersey recommendation of 2 pounds lead arsenate, 2 pounds hydrated lime, 3/4% summer oil and sticker to 100 gallons of water. The correctives compared to this plot were: (1) Weak bordeaux (1/2-2-100);(2) weak zinc sulfate-lime (1/2-2-100); (3) zinc oxide-lime (1/2-2-100); (4) sodium phosphate-copper sulfate-lime (1/2-1/2-2-100) and (5) sodium silicate-copper sulfate-lime (1/2-1/2-2-100). Foliage counts at the end of the season (September 20) showed the weak bordeaux with the lowest percentage of leaf drop and leaf burn followed closely by the zinc sulfate-lime. The sodium phosphate-copper sulfate-lime and the sodium silicate-copper sulfate-lime showed less foliage injury than the standard lead arsenate-hydrated lime-oil plot but the coverage with both of these materials was of the blotch type which lead to more worm entry and uneven coloring of the fruit.

The zinc oxide-lime plot showed very severe foliage and fruit drop beginning three weeks after the last application in August.

The so-called "triple spray" for codling moth control, first developed and tested by Hough in Virginia and later tested for three seasons in New Jersey, was observed in several orchards where this spray combination was used to control first brood codling moth. In this "triple spray" a pint of nicotine sulfate per 100 gallons of spray material is used for adult moth kill primarily, plus 3 pounds of lead arsenate to 100 gallons plus 3/4% summer oil, the lead arsenate and oil serving as a larvacide and ovicide respectively. Three different growers sprayed part of their orchards with the triple spray and part with the oil-lead arsenate spray. In each case less second brood spraying was necessary in the triple sprayed section and more clean fruit was obtained.

(2) Non-lead arsenicals. No work carried on.

(3) Fluorine compounds. No work carried on.

(4) Organic materials.

(a) Fixed nicotine compounds and Xanthone.

A series of plots using fixed nicotine with and without oil, plus a Xanthone plot, were run in comparison with lead arsenate-summer oil on three varieties (Wealthy, Stayman and Rome) in the same orchard where similar sets of plots were run in 1938 and 1939 and reported in the pool of information for those years. All of the plots were sprayed with lead arsenate at the petal fall and the first two cover sprays in 1940 to control leaf roller. This insect had injured from 7 to 14% of the apples on the Rome variety in the 1939 tests where the various nicotine treatments had begun at the first cover spray following petal fall. The different plot treatments were begun at and including the third cover spray and were continued in the fourth and fifth cover spray at approximately 10-day intervals to cover the period of first brood larval activity. The plots received four second brood sprays at approximately ten-day intervals in July and August. The results from the Rome variety only (including drops and picked fruit at harvest) are set forth in the following table.

	Treatment (in 100 Gallons)	% C. M. Stung	% C. M. Wormy	% Leaf Roller
1.	"Black Leaf 155" 4#, summer oil 2 qts.	24.9	9.9	2.3
2.	Modified "Black Leaf 155" 4#, summer oil 2 qts.	16.6	9.6	2.5
3.	"Black Leaf 155" concentrate 1 1/2#, summer oil 2 qts.	16.5	7.4	2.1
4.	"Black Leaf 155" concentrate 3#, bentonite 2# 3rd to 6th sprays, then "Black Leaf 155" concentrate 1 1/2#, oil 2 qts.7th to 9th sprays.	19.7	12.4	2.0
5.	"Black Leaf 155" concentrate 3#, oil 1 pt. oil omitted in last two cover sprays.	19.4	8.8	1.6
6.	"Black Leaf 40" 1 pt., bentonite 4#,milk 1/4# in 3rd to 5th sprays, then "Black Leaf 40" 3/4 pt., oil 2 qts. last 4 sprays.	25.2	10.9	1.3
7.	Lead arsenate 2#, lime 2#, summer oil 2 qts. Orthex 1 pt. in 3rd, 4th and 7th cover sprays; lead arsenate 3#, lime 6#, Orthex 1 pt. in 5th, 6th, 8th and 9th cover sprays.	39.2	3.1	0.2
8.	"Genicide" 2#, sodium oleate 1#, zinc sulfate 4 1/2 oz.	14.5	21.3	1.4

(b) Phenothiazine. No work carried on.

(c) Other organics. No work carried on.

B. Control by means other than spraying.

(1) Bands and sanitation. No work carried on.

(2) Baits and lights. No work carried on.

(3) Biological control.

In the pool of information dealing with results in 1939, a brief summary of the results obtained the second season of a biological control project on codling moth was given. That year (1939) there was a notable increase in egg and larval parasitization and an increase in predators in the unsprayed blocks as compared to an oil-lead arsenate sprayed orchard. In spite of the work of parasites and predators practically 100% of the crop in the unsprayed orchard was destroyed by codling moth and oriental fruit moth.

The project was continued a third season in 1940. In both the sprayed and unsprayed blocks there was a heavy set of fruit in 1940 whereas in 1939 the set was light. Egg and larval parasitization and predators (chiefly ants) again were more abundant in the unsprayed blocks as in 1938 and 1939. At harvest 90% of the fruit was wormy or stung in the unsprayed block as compared to a crop packing out 95% U. S. #1 apples in the lead arsenate-oil sprayed block. In 1940 as in 1939 oriental fruit moth was reared in considerable numbers from stung apples collected in the unsprayed blocks. The apple maggot also was reared in appreciable numbers from apples collected from the unsprayed blocks. Neither fruit moth nor apple maggot showed up in the lead arsenate-oil sprayed block.

OHIO

C. R. Cutright, Ohio Agricultural Experiment Station, Wooster.

I. The seasonal development of the codling moth was greatly retarded by low temperatures which prevailed during May and June. The first moths of the overwintering brood appeared about a week later than normal, while the first larvae under bands were taken from 10 days to 2 weeks after the date of their usual appearance. Rainfall was more abundant than normal for May and June and greatly hindered spray operations in many orchards, especially during the latter month. Despite low temperatures and abundant rainfall, an infestation of severity developed in many Ohio orchards. In fact, codling moth probably did more damage than in any year since 1934. Southern, western and northwestern Ohio experienced the greatest amount of injury while in the northeastern section the insect, as usual, was easily controlled.

II. Routine data on dates and rates of appearance of moths of the different broods and the appearance of larvae under bands were taken at Wooster and at Waterville. The shortened season of codling moth activity was clearly indicated by these data. At Waterville, O., where a codling moth emergence cage was suspended in a sour cherry tree, newly hatched codling moth larvae were found infesting a number of the fruits. Only a few of these reached the second instar and none attained maturity.

III. (a) An extensive field control experiment was conducted in the Frank Farnsworth Orchard at Waterville near Toledo, O. Here some 24 different spray schedules were tested as to their efficiency in codling moth control and their effect on fruits and foliage. Single-tree plots were employed with five replicates. Plots were laid out according to the randomized block system.

(b) The variety was Jonathan and the trees averaged approximately 35 years of age. This block was chosen because it represented the area of most severe infestation in an orchard of over 300 acres of apples.

(c) With a calyx and six covers of lead arsenate, including 3/4% summer oil in the second and third covers, damage averaged 6% wormy fruit (including dropped fruits).

(d) Damage to fruit and foliage was avoided almost entirely by using 1 or 2 pounds of zinc sulfate per 100 gallons, starting in the second cover spray. Severe injury occurred on trees receiving the straight lead and lime schedule and somewhat less on straight oil--nicotine schedules. Zinc sulfate was the most effective agent in securing good foliage while flotation sulfur applied in two or three applications was also effective. Severe russeting of fruit occurred when a cheap summer oil was substituted for the standard grade and also when Xanthone was used in the early cover sprays.

(e) Residue loads were quite high. Where schedules started with a calyx and first cover of lead arsenate and were followed by non-arsenicals and oil the lead loads averaged .040+. With full schedules of lead, Lime, oil, and zinc sulfate the lead residue was .380. Other schedules were intermediate. However, these loads were easily removed to within the legal limits by regular washing.

B. No experiments were conducted with means of control other than spraying.

Codling Moth Control
Field Experiments of 1940, Waterville, O.

Schedule	Total no. of applications	% of wormy fruit	Worms per 100 apples	Lead residue gr. per lb.
Lead arsenate 3#, lime 3# Flotation sulfur, 2nd & 4th covers	5	10	13	.38
Lead ars. 3#, lime 3#, zn. sulf. 2# Oil in 2nd & 3rd covers	5	5	6	.38
Lead ars., lime, zn. sulf. 1# Oil in 2nd & 3rd covers	5	4	5	.50
Lead ars., flot. sulf. (3 sprays) B. L. Conc. 1 1/2# in 2nd & 3rd covers	5	5	7	.38
Lead ars., lime, zn. sulf. Gulf oil 302 in 2nd & 3rd covers	5	5	7	.38
Lead ars., lime, zn. sulf. Gulf oil 371 in 2nd & 3rd covers	5	7*	9	.50
2nd cover, lead, oil, soap Lead ars., lime, zn. sulf. Oil in 3rd cover No 4th or 6th covers	3	11	16	.32
B. L. 155 4#, oil 1/2%	5	10	12	.04
B. L. 155 4#, B. L. 4 1/2 pt.	5	13	18	--
Xanthone 2#, soap & zn. sulf.	5	11*	16	--
Lead ars., lime, flot. sulf. in 1st Brood, 3 covers	5			
Kryocide - oil in 2nd Brood, 2 covers	5	5	6	--
Phenothiazine	5	23	33	--
Phenothiazine, 1st Brood, 3 covers Lead ars., 2nd Brood, 2 covers	5	12	16	.34
Lead ars., lime, flot. sulf. 1st Brood, 3 covers Phenothiazine, 2nd Brood, 2 covers	5	14	21	.20

* Fruit severely russeted. Apparently due to early-season application.

IV. The change in tolerance limits will have little effect in Ohio. Northeastern Ohio, where only one or two covers will control, will be in a somewhat more favored position. Other sections of the State that require a heavy schedule will need to continue washing. In some sections the change in tolerance will favor split schedules, with non-arsenicals against the second brood.

OREGON

L. G. Gentner, Southern Oregon Branch Experiment Station, Talent.

I. Seasonal Conditions and Codling Moth Abundance.

The first moth was caught in bait pans on April 15, one day later than in 1939. Because of cool weather, very few moths were caught until May 6. From then on, with the exception of three days - May 25, 31, and June 4, temperatures at sunset were favorable for moth flight every night until September 2. Moth catches increased rapidly, were high from May 16 to 23, then dropped rapidly. Moderate catches were made during the rest of May and all of June. Moths from first-brood worms began to fly the first part of July. Relatively high catches were made from July 9 to 25, and again from Aug. 1 to 9. Low catches continued to September 1. Very few moths were caught during September, although evening temperatures were relatively high. In a commercial apple orchard the peak catch of spring-brood moths occurred on May 18, with an average catch of 391 moths per pan; of first-brood moths on July 17, with an average catch of 97 moths per pan. A period of eight weeks and six days elapsed between the two peaks, as compared to ten weeks and three days in 1939. The bait pan placed in the same tree as in 1939 captured 4,215 moths in 1940 as compared to 4,935 in 1939. Egg deposition was almost continuous throughout the season, varying, of course in intensity.

A calyx and six cover sprays were recommended for apple trees, and a calyx and five cover sprays for pear trees. The timing of these sprays was based on moth catches in bait pans, supplemented by extensive field and insectary observations and thermographic records of temperatures at sunset.

III. Results of Control Experiments

Tests for codling moth control were made in a commercial orchard on Bartlett pears. All plots received a calyx and five cover sprays unless otherwise noted. Dates of application were as follows: calyx (extra), April 15; calyx (regular), April 19; 1st cover, May 14; 2nd cover, May 28; 3rd cover, June 18; 4th cover, July 11; 5th cover, July 30.

a. Each plot consisted of eight trees -- four random replicates of two trees each. All of the fruit from the tree and on the ground from all trees in each plot was examined for worm injury. Sprays were applied with a Bean Power sprayer at a pressure of from 400 to 450 pounds, using 2 leads of hose, Hardie spray guns, discs with 7/64 inch openings.

b. For some unknown reason, there was an unusually large number of larvae attempting to enter the fruit through the calyx end.

c. Very good control was obtained with certain combinations of materials with lead arsenate, the percentage of wormy fruit being as low as 1.3% in one plot.

Control in Commercial Bartlett Orchard

Plot and (1) Material	% Calyx Injured	% Side Injured	Total % Wormy Fruit
#1 -Lead arsenate-Fluxit (2) Brand 4 (check) Calyx and covers	3.0	3.9	6.9
#2 -Lead arsenate-Fluxit Brand 7 Calyx and covers	1.9	3.3	5.2
#3 -Lead arsenate-Fluxit Brand 8 Calyx and covers	3.0	4.0	7.0
#4 -Lead arsenate-Fluxit Brand 5 (New type) Calyx and covers	2.3	2.1	4.4
#5 -Lead ars.-Fluxit in 2 calyx applications; lead ars.-Exp.44 in covers	0.5	1.2	1.7
#6 -Lead ars.-Fluxit in calyx and covers; omitted 1st cover	5.0	5.4	10.4
#7 -Lead ars.-Fluxit in calyx and covers, omitted 2nd cover	5.3	6.2	11.5
#8 -Lead ars.-Fluxit in calyx and 4th, 5th; lead ars., 1/2 gal.Shell oil 764 in 2nd; omitted 1st and 3rd covers	5.6	6.0	11.6
#9 -Lead ars.-Fluxit in calyx and covers; omitted 3rd cover	4.2	6.0	10.2
#10 -Lead ars.-Fluxit in 2 calyx applications and covers.	1.0	2.4	3.4
#11 -Lead ars. in calyx; Brand 5 (new type) lead ars., 1 1/2 pts. Porable 90, in covers	0.9	0.9	1.8
#12 -Brand 4 lead ars., Colloidal 77, stove oil, in calyx and covers	1.2	1.7	2.9
#13 -Brand 3 lead ars., Multi-Film, stove oil, in calyx and covers	0.5	0.8	1.3
#14 -Lead ars.-Fluxit in calyx and 1st cover; Genicide, Exp. 44 in 2nd to 4th; Genicide, GX sticker, 1 pt. kerosene in 5th	3.3	8.2	11.5
#15 -Lead ars.-Fluxit in calyx; lead ars., 1 lb. rotenone 4%, Colloidal 77, stove oil, in covers	1.2	2.4	3.6
#16 -Lead ars.-Fluxit in calyx and 1st, 2nd, 3rd covers; 4 lbs. rotenone 4% in 4th and 5th	3.2	5.7	8.9
#17 -Lead ars.-Fluxit in calyx and covers; omitted 4th cover	2.5	6.2	8.7

(1) Lead arsenate was used 3 pounds in 100 gallons; Genicide 2 pounds; Fluxit 1/4 pound; Experimental 44, Colloidal 77, and Multi-Film, 1/3 pound; stove oil 1 quart.

(2) Brand 4 lead arsenate was used wherever the brand is not given.

d. No injury to either fruit or foliage was observed from any treatment used.

e. The residue load on picked fruit ranged from .066 grain of arsenous oxide per pound of fruit to .122 grain, in those plots receiving all cover sprays. This was removed to from .0035 to .0055 grain by running the fruit through a Cutler washer (flood type) containing an unheated acid bath of slightly more than 1% strength.

A. Control by Insecticides

1. Lead arsenate. The omission of any one of the cover sprays in the recommended schedule resulted in a decided increase in wormy fruit. The work of testing brands of lead arsenate was continued in a limited way. Two brands of lead arsenate not previously used experimentally were tested against Brand 4. (This had rated second in previous tests). There was no significant difference in control from that of the check lead arsenate. The new type of Brand 5 was also tested. As a result of the poor control obtained in previous tests with this brand, the manufacturers changed the physical properties of this lead arsenate, with the result that it "stepped up" from one of the poorest to one of the most effective brands of lead arsenate in 1940.

(a) The addition of 1/4 pound Fluxit to lead arsenate improves the control somewhat, but apparently is not as satisfactory for use on pears as it is on apples. The resulting cover is a blotchy, spotty type. The use of small amounts of such deposit-builders as Colloidal 77 and Multi-Film with kerosene or stove oil, or Porable 90, with the lead arsenate, results in a marked improvement in control. The resulting cover is an even, more or less granular, film. The addition of 1/2% of a summer mineral oil to the lead arsenate during periods of heavy egg deposition gives increased control in cases of heavy infestation. Where oil was added to the 2nd cover spray and the 1st and 3rd cover sprays were omitted, the control was about the same as when only 1 cover spray had been omitted in the lead arsenate-Fluxit program.

4. Organic materials.

(c) Xanthone (Genicide), substituted for lead arsenate after the 1st cover spray at the rate of 2 pounds in 100 gallons, with Experimental 44 deposit-builder resulted in control inferior to lead arsenate.

(d) One pound of 4% rotenone added to the lead arsenate-Colloidal 77-stove oil combination did not increase control. Four pounds of 4% rotenone substituted for lead arsenate in the last two cover sprays resulted in control which was inferior to the lead arsenate-Fluxit program.

B. Control by Means Other Than Spraying

3. Biological control. The egg-parasite, Trichogramma minutum, made its appearance quite early and was a factor in preventing many late entrances. Normally parasitized eggs are not to be found to any extent

until about the middle of August, or about the time of the second picking of Bartlett pears. This year a number of parasitized eggs were found as early as May 23, and parasitized eggs could be found throughout the season. At harvest time parasitized eggs were quite prevalent on the Bosc pears at the station, some of them having as many as four such eggs on them.

IV. Spray residue.

The raising of the tolerance has permitted the use of heavier spray programs in badly infested orchards than here-to-fore. There was very little difficulty in removing even a very heavy deposit of lead arsenate to meet the new tolerance.

Arsenical Residue, Before and After Washing, and Spray Deposit of Pears

Plot No.	Material and Type of Coverage	Arsenous Oxide Before Wash	After Wash	Deposit Before 5th cover	After 5th cover
		gr./lb.	gr./lb.	mmg./sq.cm.	mmg./sq.cm.
1.	Brand 4-Fluxit Blotch spots	.098	.0046	10.6	15.6
2.	Brand 7-Fluxit Blotch spots	.096	.0053	15.6	23.5
3	Brand 8-Fluxit Blotch spots	.082	.0035	15.5	20.3
4	Brand 5-Fluxit (new type) Blotch spots	.066	.0045	10.8	16.6
5	Brand 4-Fluxit, 2 calyx; Exp. 44 in covers Even granular coat	.081	.0055	8.5	15.5
10	Brand 4-Fluxit, 2 calyx	.088	.0052	---	---
11	Brand 5 (new type), Porable 90 Even granular coat	.104	.0050	18.4	30.7
12	Brand 4, 77, stove oil Even granular coat, but heavier	.122	.0048	9.8	24.8
13	Brand 3, Multi-Film, stove oil Even granular coat	.102	.0035	16.0	27.5
15	Brand 4, rotenone, 77, stove oil	.101	.0044		

The above residue and deposit analyses were made by Mr. R. H. Robinson, Chemist, Oregon Experiment Station, Corvallis.

PENNSYLVANIA

H. N. Worthley, Pennsylvania Agricultural Experiment Station, State College.

I. Seasonal conditions and codling moth abundance

From January through October, 1940, weather at Arendtsville can be characterized as cold and wet. From March through September, there was an accumulated temperature deficiency of 12.1° F., and an accumulated excess rainfall of 5.33 inches. Of 1600 codling moth larvae that cocooned in corrugated strawboard in tree-trunk cages during the summer and fall of 1939, 90% produced moths in the spring of 1940. Seasonal development of the codling moth was about a week later than in 1939. Heavy first brood infestations followed lax spray programs. Warm evenings during the second and third weeks in August favored flight and oviposition of first brood moths, and was followed by an increase in "stung" apples. Worminess increased wherever arsenical deposits remaining from earlier sprays were deficient. Observed dates of codling moth occurrence in 1940 were as follows:

	State College (Central)	Arendtsville (S. Central)
Spring moth emergence - began	May 29*	May 18
- 50%	June 15*	June 9
- ceased		July 1
First larval entrance into fruit		June 5
Earliest mature 1st brood larvae		July 5?
First generation emergence - began		July 19
- 50%	August 9*	August 1
- ceased		Sept. 3
Last moth in bait pails	Sept. 4	Sept. 18?

*As judged by bait pail catches

III. Results of control experiments

A. Control by insecticides

(1) Lead arsenate: Included in a setup of 25 treatments, 9 spray mixtures were tested for codling moth control in first brood spray schedules. Single tree plots were randomized within 6 replicated blocks in an orchard of mature Stayman Winesap trees. Under these circumstances all the arsenical mixtures gave a high degree of control of first brood larvae, but the abbreviated "high deposit" schedules presented such reduced deposits by August that only partial control was obtained of larvae resulting from moth emergence in other trees in the test block, on which inadequate first brood control was obtained. Inverted spray mixtures containing lead arsenate at 6 pounds per hundred gallons, and applied at double the usual dosage in the second (final poison) cover spray on June 12 produced from 57 to 65 percent clean fruit and from 17 to 27 worms per hundred apples in counts involving both

dropped and picked fruit (table 1, treatments 2-5, 7-9). Lead arsenate at 3 pounds per hundred gallons, and applied at usual dosages in 5 cover sprays ending on July 16 (table 1, treatment 1), gave no higher percentage of clean fruit and no better protection against first brood worm entries, although this treatment required 3 more spray applications and nearly twice as much spray material (compare treatments 1 and 2, table 1). However, the late applications protected the fruit against the attack of second brood larvae, so that counts of the total crop showed about one-third as many worms at harvest as in the "dynamite" treatments.

(3) Other inorganic materials: Cryolite at 6 pounds per hundred gallons was tried in a "dynamite" mixture (table 1, treatment 6). In comparison with treatment 2 it showed 6 times as many worms on July 23 and 3 times as many at harvest.

The spray mixtures used appeared to have little or no effect on spray injury to the fruit, or on fruit drop. In some treatments, however, the foliage showed extensive injury in late summer, of the sort attributed to soluble arsenic. Counts of the injured foliage were made from September 12 to 16, the samples comprising 100 consecutive leaves on branches selected at random in each quarter of every tree. The third cover spray of Bordeaux mixture, applied in treatments 4-9 on July 16, was evidently too late to afford more than partial protection against this injury.

(4) Organic materials: Various substitutes for inorganic poisons were tested in 2 second brood applications to young Rome Beauty trees interplanted with peach, and showing considerable damage from first brood codling moth attack. Single tree plots were used, 9 treatments being randomized with 6 replicated blocks. Table 2.

The USDA formula for tank-mixed nicotine bentonite gave outstanding results (table 2, treatment 2), apparently affording complete protection against codling moth attack. However, the results of this experiment must be taken as suggestive rather than conclusive, due to variation in results not associated either with treatment or replicate. GENECIDE (treatment 1) and BLACK LEAF 155 CONCENTRATE (treatment 4) appeared to be about equal. Rotenone in various forms (treatments 7, 8, 9) was inferior to other materials. No injury to fruit appeared, nor any differences in fruit drop associated with treatment. A small percentage of the leaves sprayed with GENECIDE showed light colored necrotic areas along the principal veins.

IV. Spray residue

Lead arsenate remains the cheapest and most effective insecticide for control of the codling moth in Pennsylvania. With tolerances for lead and arsenic at .025 and .01 grains per pound, respectively, it has been impossible to apply a schedule of first brood sprays adequate to give continued protection against the partial second brood of larvae, without leaving harvest residues at a point requiring washing. It is thought that the increased tolerances will allow the use of lead arsenate until mid-July.

Table 1. First brood codling moth spraying experiments. Stayman Winesap. Baugher Orchard, Aspers, Pa., 1940. Single tree plots. 6 replicates.

Treat. No.	Schedule and materials Amts. per 100 gals. spray	Clean Fruit %	Worms per 100 apples: Jul 23	Worms per 100 apples: Harvest	Spray-burned: Fruit %	Spray-burned: Foliage %	Lead Grains per Lb.
1	L. arsenate 3#, lime sulfur 1.3 gals. sk.milk powd. 0.5# mang. sulf. 4 oz. 6/6, 6/11,* 6/17, 6/27, 7/16.	59.7	1.1	6.8	8.8	49.3	.035
First cover spray as above in all following treatments							
2	2nd cover L. arsen. 6#, (a) fuel oil 1350 ml., fish oil 450 ml., oleic acid 95 ml. (b) monoethanolamine 18 ml., water 218 ml. 6/12. See note 1.	59.1	1.6	20.8	12.0	74.6	.020
3	2nd cover as treat. 2. 3rd cover lime sulfur 1.3 gals. hyd. lime 3#, 7/16.	58.4	1.0	21.5	11.8	70.2	.024
Third cover spray 2-4-100 Bordeaux, 7/16, in all following treatments							
4	2nd cover as in treat. 2.	58.0	1.3	25.9	12.5	54.7	.017
5	2nd cover as in treat. 2, plus nicotine sulf. 1 pint	57.5	1.5	20.9	12.7	61.0	.022
6	2nd cover ALORCO cryolite 6#, (a) fuel oil 1419 ml., fish oil 473 ml., (b) ammonium oleate 91 gms. (c) zinc sulf. solution 1 qt. (crystals 23% Zn, 0.5#/Gal.). See note 2.	46.9	7.1	63.0	15.7	32.5	.011
7	2nd cover L. arsen. 6#, Sh-W. Summer oil Emulsion 1.25 qts. SPREDRITE 1 pint, 6/12.	65.1	1.1	17.0	11.0	40.2	.028
8	2nd cover L. arsen. 6#, ORTHEX 3 pints, 6/12.	61.1	0.6	22.2	11.8	45.4	.023
9	2nd cover 1. arsen. 6#, SPRAYLASTIC 3 pints, 6/12.	57.8	1.1	27.3	10.0	42.5	.018
0	No spray treatment	21.9	59.0	140.3	10.0	14.7	-
Least sig. diff. at 1% level		12.4	3.3	15.7		12.5	

*Spray directed at tops of trees only.

Note 1. (b) placed in 1 gal. water, (a) stirred in. Mixture added to lead arsenate suspension in nearly full tank. Oleic acid in (a) omitted by mistake.

Note 2. (b) and (a) handled as in Note 1. (c) not needed; designed to be added slowly to inverted mixtures to produce desired flocculation; made by mixing 80 gms. 95% oleic acid and 128 ml. 28% ammonia.

Table 2. Second brood codling moth spraying experiments. Rome Beauty. Heacock Orchard, Biglerville, Pa., 1940. Single tree plots, 6 replicates.

Treat. No.	Materials applied Aug. 8 and 20. Amounts per 100 gallons of spray	Counts of all drop and picked fruit at harvest			
		Clean Fruit %	Wormy Fruit %	Stung Fruit %	Worms per 100 apples
	Injury previous to treatment	65	13	28	16
2	Nicotine sulfate 1 pint, Wyoming bentonite 5#, soybean oil 1 qt.	64	12	30	17
4	BLACK LEAF 155 CONCENTRATE 3#	49	21	41	26
1	GENECIDE 2#, sodium oleate 1#, mono-hyd. zinc sulf. 4.5 oz.	56	17	37	27
3	Nicotine sulfate 1 pint, Wyoming bentonite 5#, stirred together the evening previous to spraying	52	19	39	28
6	NICOMULSION .75 gal.	48	21	44	31
5	BLACK LEAF 155 CONC. 1.5#, SUN Summer Oil 0.5% oil	51	21	38	33
8	Cube root (4% rotenone) 3#, NNO 1 pint	52	24	39	48
7	D-X 1.5 pints	44	27	46	53
9	SYNTONE (2.8% rotenone) 1 qt.	42	31	45	57
0	No second brood sprays	40	36	43	68
Least sig. diff. at 1% level		12.1	13.0		38.1

UTAH

C. J. Sorenson, Agricultural Experiment Station, Logan.

With reference to the codling moth situation in this state during 1940, it should be said that the winter season of 1939-40 was relatively mild and during the growing season of 1940, there was sub-normal rainfall and high temperatures prevailed.

In consequence of these seasonal conditions, there was a high winter survival of codling moth and a considerable build-up of the summer broods. Because of increased numbers during the summer, control was more difficult, necessitating the application of from one to two additional cover sprays. In orchards which were not adequately sprayed, considerable damage resulted.

No investigational work has been done at this Station during recent years with reference to the biology of the codling moth. Neither have any experiments been performed for its control.

VIRGINIA

M. L. Bobb, Piedmont Fruit Research Laboratory, Virginia Agricultural Experiment Station, Charlottesville.

I. Seasonal Conditions and Codling Moth Abundance.

Emergence of spring-brood codling moths began on May 8 which is the latest starting date of emergence since 1935. The moths emerged rapidly and the peak of emergence occurred from May 16-20. Some unusual condition seemed to lower the resistance of the larvae to arsenical sprays with the result that fruit from well sprayed orchards showed less worm injury than for several years, while on the other hand, fruit from unsprayed or poorly sprayed orchards was moderately to heavily injured by the codling moth.

II. Results of Experiments.

B. Control by means other than spraying.

1. Bait trap studies.

The tests of baits for use in codling moth traps were continued, but only five materials were tested. As in previous years, quart oil cans which were painted inside and outside with aluminum paint were used as traps. After being filled with the desired solution the traps were suspended from a stout limb in the upper third of each tree in the test blocks. The basic

solution consisted of stock syrup (barrel molasses) at the rate of 1 part to 20 parts of water. The attrahents were emulsified with a 5 percent mixture of bentonite in water and were added to the basic solution at the rate of 1 cc. per trap. The tests were conducted from May 9 to July 25.

Of the five materials tested; namely, anethol, calamus oil, geranium oil, lemon oil, and stock syrup alone, anethol captured approximately twice as many moths as the next best material (lemon oil). Traps containing calamus oil in the basic solution of molasses captured the least number of moths.

Experiments on the use of bait traps as an aid in controlling the codling moth were made in the same large Winesap orchard in which like tests were made in 1939. A square block of 100 apple trees was selected in the center of the orchard and a trap was suspended in the upper third of each tree. The traps were of the quart-tin-can type and each was filled with a bait consisting of 1 part of stock syrup to 20 parts of water plus 1 cc. of anethol per quart of solution. The traps were put up when the spring-brood moths began to emerge and were continued in operation until after the emergence of second brood moths, or until late September. Approximately every three weeks the bait in the traps was replenished and at the beginning of each brood of moth emergence the traps were emptied and refilled with fresh bait mixture.

Four trees in the center of the baited block and one tree on each side of the baited block five rows out in the unbaited sections were selected to be used for fruit counts at harvest. All drops beneath the trees from July 1 to harvest were picked up and scored. All apples picked at harvest were likewise scored. All trees on which counts were made bore a moderate crop of fruit. See table below.

Items	Picked fruits		Drop fruits	
	Baited	Not baited	Baited	Not baited
Total apples	4644	3817	61	75
Percent clean	96.96	89.23	93.44	52.00
Percent stung	2.91	8.54	3.28	2.67
Percent wormy	0.13	2.23	3.28	45.33
Percent increase in clean fruit	7.73	---	41.44	---

Average percent increase in clean fruit was 8.41 (includes picked and drop fruits).

VIRGINIA

W. S. Hough, Winchester Research Laboratory, Virginia Agricultural Experiment Station, Winchester.

Codling moth injury in commercial orchards was greatly reduced due to the cool, wet weather that prevailed during May, June and August. On the other hand, injury was about normal on unsprayed trees.

Summary of the experimental results is given in Tables 1 and 2. The results include examination of the drops from July until harvest time and random sampling of the picked fruit.

Each plat in Table 1 included two trees of the Stayman variety and three trees of the King David variety. The varieties were located in different sections of the orchard. The plats of Table 2 were in Latin squares of twelve trees per square. Each plat was replicated for each variety and the nicotine plats alternated with the arsenical plats.

Where lead arsenate was used alone (Plat 9) or with brown sugar (Plat 10) severe defoliation occurred especially on the King David variety. Foliage injury was so severe in Plat 10 that it was necessary to discontinue brown sugar after the fourth cover spray.

The light Bordeaux mixture and the zinc correctives listed in Plats 11 to 15 greatly reduced arsenical injury on the foliage. The zinc correctives, however, were slightly less effective in the reduction of arsenical injury and in the case of zinc sulphate there appeared to be a tendency to alter the effectiveness of the lead arsenate similar to the effect observed in other seasons.

Xanthone (Plat 8) applied at intervals of ten days during the period of activity of the first and second broods compared favorably with lead arsenate (Plat 9) in total injuries but the percentage of wormy apples was doubled on each variety where Xanthone was used. A slight purple stippling developed on the foliage and to some extent on the fruit of the King David variety where Xanthone was used, but the effect was of no practical importance.

Reduction of lead arsenate to two pounds in the fifth and sixth cover sprays containing rotenone (Berako Fruit Spray) increased the percentage of wormy apples on trees where the fruit had been unusually clean up to that time.

Oil injury was evident on the fruit in Plat 6.

Nicotine in all schedules gave excellent control and the condition of the fruit and foliage was excellent.

Copper injury was conspicuous on the foliage in Plats "L" and "L-".

The increased tolerances for lead and arsenic will permit the use of lead arsenate in all orchards through the middle of July, but in heavily sprayed orchards it will be necessary to continue washing the fruit where the usual practice is to apply a lead arsenate cover spray against the second brood in late July or early August.

Table 1.- Results of experiments at Winchester, Va.

Plat No.	Spray program and amount of insecticide per 100 gallons.	Percent injury: Stayman variety	Percent injury: King David variety	Lead residue (gr./lb.): Stayman variety	Lead residue (gr./lb.): King David variety
	Lead arsenate 3 lbs. and a sulfur fungicide in calyx & 1st cover sprays in all plats.				
1.	Black Leaf 155 4# & Orthol-K 2 qts. in 7 covers ending Aug. 13.	1.7	14.0	.025	.028
2.	Modified Black Leaf 155 4# & Orthol-K 2 qts. in 7 covers ending Aug. 13.	1.5	9.1	.022	.027
3.	Black Leaf 155 Concentrate 1 1/2# & Orthol-K 2 qts. in 7 covers ending Aug. 13.	2.9	3.9	.034	.028
4.	Black Leaf 155 Concentrate 3# & bentonite 2# 2nd-4th covers & Black Leaf 155 Concentrate 1 1/2# & Orthol-K 2 qts. 5th-8th covers ending Aug. 13.	2.5	4.9	.022	.023
5.	Black Leaf 155 Concentrate 3# & Orthol-K 1 pt. in 7 covers ending Aug. 13.	2.7	6.0	.011	.024
6.	Sherwin-Williams nicotine-oil emulsion 1 gal. in 7 covers ending Aug. 13.	2.6	3.4	.019	.019
7.	DX 1 pt. in 1st,3rd,4th,6th covers, 1 1/2 pts. in 2nd & 5th covers. $PbHAsO_4$ 3# 2nd,3rd & 6th covers & 2# 4th & 5th covers.6th cover ending Aug. 9.	7.5	14.2	.107	.162
8.	Genicide 2#, sodium oleate 1# & zinc sulfate 4 1/2 oz. in 2nd-7th covers ending August 13.	9.6	18.2	.026	.028
9.	Lead arsenate 3# in 2nd to 6th covers ending August 9.	14.1	9.6	.125	.167
10.	$PbHAsO_4$ 3# 2nd-6th covers, sugar 16# 2nd-4th covers, lime 3# 5th cover & 2-4-100 Bordeaux in 6th cover ending August 9.	16.4	2.8	.096	.180

Table 1 - Continued

Plat No.	Spray program and amount of insecticide per 100 gallons	Percent injury: Stayman variety	Percent injury: King David variety	Lead residue (gr./lb.): Stayman variety	Lead residue (gr./lb.): King David variety
11.	$PbHAsO_4$ 3#, 1/2-1-100 Bordeaux 1st to 6th covers. Sherwin-Williams medium oil 3 Qts. 2nd cover & S-W light oil 3 qts. 3rd-6th covers ending Aug. 9.	3.0	6.4	.180	.240
12.	Same as Plat 11 except medium oil was used in 2nd to 6th covers.	4.3	7.2	.230	.257
13.	$PbHAsO_4$ 3#, lime 1# & zinc sulfate 1/2# in 1st to 6th covers ending August 9.	14.7	24.2	.110	.160
14.	$PbHAsO_4$ 3#, lime 2# & zinc sulfate 1# in 1st to 6th covers ending August 9.	12.9	19.4	.080	.130
15.	$PbHAsO_4$ 3#, lime 1# & zinc oxide 1/2# in 1st to 6th covers ending August 9.	9.5	10.1	.093	.134
16.	Black Leaf-40 3/4 pt. 2nd-3rd covers. $PbHAsO_4$ 3# 1st-4th covers & 2# in 5th & 6th covers. Berako Fruit Spray 1 qt. 4th-6th covers ending August 9.	13.7	13.7	.099	.095
	Checks, not sprayed after calyx.	92.1	67.3	.010	.007

Table 2. - Results of abbreviated schedules employing nicotine, Winchester, Va.

Spray program and amount of insecticide per 100 gallons.	Variety	Percent Total injured:	Percent Wormy:	Lead residue (gr/lb)
Lead arsenate 3 lbs. & Sulfix sulfur 5 lbs. in calyx and 1st cover all plats.				
Plat (B-1)				
Black Leaf 155 4# in 2nd-3rd and 5th & 6th covers.	Delicious	4.9	0.95	.015
Oil emulsion 3 qts. in 2nd-4th covers & 2 qts. in 5th & 6th covers. Black Leaf-40 3/4 pt. in 2nd-4th covers.	King David	3.4	0.25	.027
Plat (B-2)				
Black Leaf 155 Concentrate 4# in 2nd-3rd covers, 2 1/2# in 4th cover & 1 1/2# in 5th & 6th covers.	Delicious	2.9	0.85	.011
Oil emulsion 3 qts. in 2nd to 4th covers & 2 qts. in 5th & 6th covers.	King David	3.0	0.03	.021
Plat (L-)				
Lead arsenate 3# in 2nd to 6th covers. 2-4-100 Bordeaux in 2nd to 6th covers.	Delicious	10.3	0.8	.098
Spraylastic 1 pt. in 2nd to 6th covers.	King David	10.4	0.65	.145
Plat (L)				
Lead arsenate 3# in 2nd to 6th covers.	Delicious	7.2	0.7	.160
2-4-100 Bordeaux in 2nd to 6th covers.	King David	8.2	0.04	.180
Checks, not sprayed after calyx	Stayman	92.1	92.1	.010
	King David	67.3	67.1	.007

Note: Date's for above sprays: calyx, May 16-18; covers on May 30-31, June 13, 21, 29-July 1, July 24 and August 8.

VIRGINIA

A. M. Woodside, Virginia Agricultural Experiment Station (Staunton Field Laboratory), Staunton.

I. Seasonal Conditions and Codling Moth Abundance.

Emergence of spring-brood moths began in the insectary on May 14, slightly later than the average date. Moths first appeared in bait traps on May 15. Insectary emergence reached a peak on May 19, and the maximum catches in bait traps were on May 21, with a period of heavy flight continuing through the first week of June. Total emergence was somewhat lighter than in 1938 and 1939. Maximum oviposition in the insectary took place June 3-6. Hatching in the orchard, as evidenced by the number of stings and entries on small trees, reached a peak about June 21, with a second unexplained peak on July 2. Weather during May and June was generally favorable to the codling moth, except for a period of eleven days beginning on June 8 when rain fell daily. In spite of generally favorable conditions the infestation was lighter than for the past three years. Flight of first-brood moths reached a peak about the end of July. Stings and entries maintained a fairly uniform level through the last half of July and in August, with a peak on August 19. Rainfall during these two months was more than double normal, and aided greatly in reducing damage. Losses from the attacks of codling moth were much lower than for the past three seasons. There was no third brood, and the population of hibernating larvae is lower than at any time in the past seven years.

II. Studies on codling moth behavior.

To determine to what extent codling moth larvae might be hibernating on the ground, cheesecloth cages were constructed under three apple trees. Each cage covered one-fourth of the area beneath the tree, but excluded the trunk. The soil under the first tree was almost bare, that under the second bore a moderate cover of grass and poison ivy, and that under the third was bare of vegetation, but had a heavy cover of dead leaves. On the first tree 147 larvae had cocooned in 1939; on the second, 121; and on the third, 100. One moth emerged in each of the first two cages, none in the third. Codling moth larvae placed under these cages pupated and emerged as readily as did others placed outside, although they did so slightly later.

III. Results of Control Experiments.

B. Control by other means than spraying.

1. Bands. The catch in bands was very low. It is doubtful if the results this season, even in heavily infested orchards, justified the expense of their use. Numbers of larvae elsewhere on the trees were correspondingly low. A block of 100 apple trees in a moderately infested orchard was banded and a bait trap filled with molasses-water mixture 1-20 and with 1 cc. anethol added to each quart pail was placed in each tree. The fruit from the banded and baited block contained 2.6 worms and 22.9

total injuries per 100 fruits, while that from the surrounding area contained 5.2 worms and 45.1 total injuries per 100 fruits. Aside from banding and baiting the treatment was the same throughout the orchard.

2. Bait pails were placed in each of 100 apple trees in a heavily infested orchard. The bait trap consisted of a quart oil can filled with a mixture of one part of molasses and 20 parts of water. To each can was added 1 cc. of anethol emulsified with bentonite. The liquid was replenished as it evaporated or spilled. When first-brood moths began to emerge the cans were emptied and refilled. Aside from the bait traps the treatment of the orchard was uniform. There were 5.5 worms and 28.2 total injuries per 100 fruits in the baited block and 7.2 worms and 60.0 total injuries per 100 fruits outside this block.

WASHINGTON

R. L. Webster, W. J. O'Neill, and Herman Fallscheer,
Washington Agricultural Experiment Station, Pullman and Wenatchee.

I. Seasonal Conditions

Temperatures for August and September at Wenatchee were above normal, conducive to a great deal of worm activity immediately previous to harvest. Mean temperature for August was 73.4, which was 1.08 degrees above normal; for September 67.9, which was 6.3 degrees above normal.

II. Studies on Codling Moth Biology or Behavior.

Again an attempt was made to determine the correlation between peaks of moth activity in spring and peaks of worm entrance as it occurs several weeks later. In 1939 the peak of worm entrance, as measured by the removal of wormy apples every two days on unsprayed Jonathan trees, was between 25 and 30 days. In 1940 the interval was shorter, and the peak of worm entrance occurred about 10-12 days following the peak of overwintering moths caught in bait traps.

III. Results of Experimental Work

A. Control by insecticides.

(3) Other inorganic materials.

Detailed studies on the ovicidal value of mineral oil for codling moth were conducted during the summer of 1940, at 0.5 percent concentration. A 55 viscosity oil was found to have fully as much ovicidal value as an oil with a viscosity of 65, or 77 Saybolt. Previous investigations had indicated a lower ovicidal value for oils with a viscosity of 55.

A combination of rotenone-lead arsenate-stove oil-multifilm and soap was tried out in 1940, following the report of the use of such a combination in 1939 by a successful grower. Sixty percent of the harvested fruit was wormy.

(4) Organic materials.

(a) Fixed nicotine. Investigations with nicotine bentonite in the experimental orchard corroborate results of 1939, which indicated that codling moth control where 1 pint, 3/4 pint, and 1/2 pint nicotine sulfate per 100 gallons was utilized, was in direct proportion to the quantity of nicotine used. Analysis showed that nicotine residues also corresponded to the concentration used. The 1939 results indicated that the deposit of not less than 34 micrograms per square inch, maintained throughout the season, was necessary to control the codling moth in the heavily infested Wenatchee district.

(c) Xanthone. Applications of this material during the early cover sprays resulted in some little foliage injury. Later applications did not aggravate the injury. Xanthone sprays did not give the outstanding control exhibited the previous season, though the control was equal to the check plots of modified inverted lead arsenate.

B. Control by Means Other than Spraying.

(2) Baits and Lights.

Three blocks of grafted Delicious trees in the experimental orchard at Wenatchee were utilized for some experiments with light to attract the codling moth. All trees received the regular cover sprays, utilized commercially elsewhere in the orchard. In Block A, consisting of 10 untreated trees, there were 39.3% wormy apples. In Block B, provided with two monolites, there were 39.4% wormy apples. In Block C consisting of 16 trees with two monolites, there were 33.6% wormy apples. Drops and harvested fruits were included in these counts. It did not appear that any advantage was obtained in this case by the use of the lights in these two blocks.

Lights were relatively inefficient during the period of first brood activity as compared to bait traps established elsewhere in the orchard. Apparently the bait traps function during the period of moth activity at dusk, before the lights begin to attract the moths. Because of low temperatures immediately after sunset in early spring, the monolites attracted few moths during that period.

During the summer time moth catches at the lights were high, but it was felt that these high catches were in a large measure a result of the inefficiency of the traps earlier in the season.

IV. Spray residue

A. Effect of tolerance changes on the local problem.

In spite of the increase in lead and arsenic tolerances, most lots of fruit sprayed throughout the season with lead arsenate in commercial combinations still require tandem washing machines to effect commercial cleaning. A reduction in temperature of the washing solution has generally been effected, however. Certain lots of fruit when washed at reduced temperature, however, showed visible residue even though the lead residue was below the .05 tolerance. Fruit sprayed with cryolite in the late cover sprays required a severe washing program where more than three cryolite sprays were used.

WISCONSIN

John A. Callenbach, Wisconsin Agricultural Experiment Station, Madison.

I. Seasonal conditions and codling moth abundance during the 1940 season.

A study made several years ago of the influence of weather on codling moth abundance in southwestern Wisconsin indicated that seasons which approached the monthly average for May - August inclusive, were light codling moth years. These average seasons usually have a cool wet spring and heavy rainfall in the latter part of August. The 1940 season approached these average conditions and codling moth infestations were generally light.

More codling moth injury was reported than was warranted by the codling moth abundance. This is probably explained by failure of growers to properly time their codling moth sprays. The 1939 season was 10 days to two weeks ahead of the average and many growers who did not employ bait pans or other timing methods based their 1940 spray schedule on the 1939 schedule.

III. Results of control studies.

These investigations were greatly curtailed by lack of sufficiently heavy infestation.

A. Control by insecticides.

(1) A study on the use of stickers and spreaders with lead arsenate has been undertaken but results are not yet available.

(4) In 1940, five series of plots in three different orchards were applied but only one series yielded significant data. The experimental set-up for this series was as follows:

The variety used was McIntosh, the trees about 20 years old and in excellent condition. Plots were composed of 4 trees each, the trees being randomly placed, generally 2 trees together. The sprays were applied with a Bean No. 33 self-propelled sprayer. A pressure of 325 pounds was maintained. A Hamilton gun with approximately a 1/16" aperture in the disc was used. Approximately 10-12 gallons per tree was applied.

Table I.- McIntosh Plots at Sunrise Orchards, Gays Mills, Wisconsin, 1940.

Plot	Treatment	No. Fruit	% Clean	Stings No.	Stings %	Worms No.	Worms %	% Stings and Worms
1	Lead arsenate 2-100 Lime 2-100 Dried milk 1-100	514	84.0	111	21.6	19	3.7	25.3
2	Black Leaf 155 4-100	560	86.4	81	14.5	41	7.3	21.8
3	Black Leaf 155 conc. 3-100	450	83.6	68	15.1	35	7.8	22.9
4	Cream of Agicide 1-400	690	86.2	101	14.6	52	7.5	22.1
5	Agicide (DC-d-S) 4-100	475	79.6	87	18.3	61	12.8	31.1
6	Botano-N 8-100	610	87.4	70	11.5	50	8.2	19.7
7	Botano-R 8-100	620	81.4	105	16.9	97	15.7	32.6
8	Nico-Sol powder 1-100 Nico-Sol 1-200	550	84.0	115	20.9	45	8.2	29.1
9	Black Leaf 155 4-100 Summer oil 1-200	750	90.5	59	7.9	35	4.7	12.6
10	McConnon 114-Y-2, 3/4 pt.-100	420	80.7	71	16.9	56	13.3	30.2
11	McConnon 115-J-1, 3/4 pt.-100	455	80.0	106	23.3	45	9.9	33.2
12	McConnon 114-Y-2, 3/4 pt.-100 Summer oil 1-200	675	88.0	95	14.1	35	5.2	19.3
13	Black Leaf 155 8-100	620	88.7	61	9.8	42	6.8	16.6

Note: Plots 1-9 sprayed August 8, Plots 10-13 sprayed August 9.

The test materials may be placed in three general categories: (1) those containing lead arsenate as the toxic agent, (2) those containing a fixed nicotine, and (3) those containing rotenone. Each of the latter two may be subdivided into those used alone and those used in combination with a summer oil.

The results may be summerized as follows:

1. Lead arsenate and fixed nicotine gave about equal control while rotenone was generally inferior.

2. Addition of a summer oil increased the effectiveness of nicotine and rotenone sprays (Nico-Sol failed to give the superior results obtained last year.)

3. Lead arsenate gave superior worm control but allowed a greater number of stings, while nicotine reduced the number of stings but allowed the number of worms to increase.

4. Oil again reduced the bloom on McIntosh but not to as great an extent as last year. This is a serious objection to the use of a summer oil (on McIntosh in Wisconsin).

IV. Spray residue.

A. Tolerance changes have practically eliminated the residue problem in Wisconsin insofar as toxic residue is concerned; visible residue still remains a problem.

CANADA

W. G. Garlick, Dominion Entomological Laboratory, Vineland Station, Ontario.

I. Seasonal Conditions and Abundance

As a general statement it may be said the spring was very backward, followed by many rains and often cool temperatures. As a result injury appeared later than usual and the proportion of stings was rather high. There was a large carry-over from 1939. Bait pail records showed that 80% of the season's catch was spring brood moths and that the total moth population was higher than it has been since 1937. Insectary rearings indicated that the number of first brood larvae reaching the adult stage was 12% below average.

The calyx spray, in the Niagara district, was applied a week later than any year in the past ten. Eggs laid on June 19 took sixteen days to hatch. However, from about the middle of July to the middle of August the

incubation period was five to six days only. Pupae were found in the orchard up to the last two weeks in October, later than noted before.

II. Studies on Behaviour

a) Effect of change of climate - Material, originally from Nova Scotia, has been reared for the second year at this Station. The proportion of second brood larvae, though it showed an increase over last year, was again lower than in local material. The figures were: Nova Scotian material 15%, and local material 38% second brood. This would indicate that the adaptation to a changed climate, though rapid, does take an appreciable time.

b) Disposition of total trapped larvae where both trunk and main limbs banded - In 1939 three trees were selected at random in an unsprayed orchard of mixed varieties. Three-ply burlap bands were applied on the trunk six inches above ground level and on all scaffold branches above the crotch. Two-inch barricades of tanglefoot were placed above the trunk band and below the branch bands.

From July 6 to August 11, 61% of the total unparasitized and 78.5% of the total parasitized (by Ascogaster) larvae taken from the trees were trapped in the branch bands. Of the total larvae collected from August 12 to October 10 only 16.7% of the unparasitized and 35.7% of the parasitized were secured from the branch bands. The figures indicated that a large proportion of first brood mature larvae left the fruit, before it dropped, to seek cocooning locations. The reverse was true for second brood larvae.

c) Proportion of larvae trapped in paper and burlap trunk bands - Trees were banded in 1940 with three-ply burlap and others with a two-inch corrugated pasteboard strip protected by a broader strip of opaque paper. The number of infested fruits on these trees was counted. The figures are given below.

Variety	Band Type	# Larvae	# Infested Fruits	% Trapped
Fameuse	Burlap	626	5,578	11.2
"	Paper	782	4,612	17.0
McIntosh	Burlap	726	4,025	18.0
"	Paper	1,036	3,442	30.1
"	Paper	533	1,821	29.3

The above figures, based only on a small experiment, indicated that the paper bands were more efficient than the burlap, particularly on McIntosh. The total number of larvae was taken to be the same as the number of infested fruits (i.e. one larva per infested fruit, regardless of the number of holes actually present). Some inaccuracies were doubtless caused by re-entries of codling moth larvae and infestation by oriental fruit moth larvae but these were not sufficient to account for the difference between the number trapped and the number maturing on the trees.

III. Results of Control Experiments

Below are given the results of tests in a block of Fameuse trees. Plot 1, the standard, was replicated six times and the remaining plots were in duplicate. Plots consisted in the main of six trees. Counts were taken by random sampling of picked fruit only, 500 fruits per tree.

Where a minimum of oil was used (plot 8), the control was decidedly inferior. This plot also showed a bronzing of the foliage. Brown sugar (plot 10) caused considerable injury to foliage, apparently increasing oil penetration and in addition there was a marked dropping of the fruit. Condition of fruit and foliage in other plots was good. Plot 7 would seem to indicate some value from the addition of zinc sulphate. In this connection it may be mentioned that plots were set up in a McIntosh orchard using varying amounts of zinc sulphate and none at all. Analyses indicated the addition of this material did not aid in building up or retaining arsenic on the fruit.

Fameuse Orchard

Schedule	Plot	Tot. Fruit	% Clean	% Deep	% Stings
Standard	1	13,000	48.4	15.2	36.4
Botano-N	2	5,500	51.6	18.0	30.4
Kolofix, nicotine sulphate with 1/2 % oil	3	5,500	52.3	11.0	36.7
Cryolite	4	5,500	51.7	17.0	31.3
1/2% oil in covers 2,3,4	5	5,000	50.3	16.0	33.7
1%,1/2%,1% in 2,3,4 covers	6	5,500	50.9	15.2	33.9
Zn. sulphate in 1,2,3,covers	7	5,500	57.1	12.5	30.4
Oil 1/2% in 4 only	8	4,000	30.7	14.9	54.4
Kolofix, nicotine sulphate without oil	9	5,000	54.6	8.6	36.8
Brown sugar in 3, 4	10	4,500	55.8	14.2	30.0

All plots received 4 cover sprays (first brood). Quantities of materials below are for 40 Imp. gal.

Calyx - All plots, Kolofog 3 lbs., Lead arsenate 2 lbs.

Plot 1 - 1st Cover, Coposil 1 lb., L. A. 2 lbs., lime 2 lbs.
2nd " , Coposil 1 lb., L. A. 1 1/2 lbs., lime 2 lbs., oil 1%.
3rd " , L. A. 1 1/2 lbs., lime 3 lbs., oil 1%.
4th " , Black Leaf 155, 3 lbs., oil 1/2%.

Plot 2 - Same as 1 but Botano-N 3 lbs., instead of B.L. 155.

Plot 3 - Same as 1 but Kolofix 1 1/2 lbs., nicotine sulphate 1/2 pint instead of B. L. 155.

Plot 4 - Same as 1 but cryolite 1 1/2 lbs., instead of B. L. 155.

Plot 5 - Same as 1 but 1% oil in 4th instead of 1/2% oil.

Plot 6 - Same as 1 but 1/2% oil in 3rd and 1% in 4th.

Plot 7 - Same as 1 but Zinc sulphate 1/2 lb., additional in 1st, 2nd, and 3rd.

Plot 8 - 1st Cover, Kolofog 3 lbs., L. A. 2 lbs.
2nd " , Kolofog 3 lbs., L. A. 1 1/2 lbs.
3rd " , L. A. 1 1/2 lbs., lime 3 lbs.
4th " , B. L. 155, 3 lbs., oil 1/2%.

Plot 9 - Same as 1 but Kolofix 1 1/2 lbs., nicotine sulphate 1/2 pint instead of B. L. 155. No oil used in 4th.

Plot 10 - Same as 1 but brown sugar 8 lbs., additional in 3rd, 4th.

For specifications of oil used see #1 under Oils as Ovicides. Oil was emulsified with calcium caseinate, 2 oz. per Imp. gal.
Dates sprays applied - Calyx, June 3-4; 1st cover, June 14-15; 2nd June 25-27; 3rd, July 5-6; 4th, July 17-18.

H. E. S. #7 Orchard

This small orchard, of mixed varieties, was all sprayed in 1939, the average of all plots being, clean 83%, deep 13% and stings 4%. This season half the orchard (plot 4) was unsprayed (for codling moth) and the other half divided into 3 single plots. The setup was designed to show the injury which might be expected from overdoses of oil and the value of oil alone in codling moth control. Three varieties, McIntosh, Ontario and Cranberry were used in the counts and the figures below include all fruits, dropped and picked.

Cover Sprays	Plot	# Trees Counted	Tot. Fruit	% Clean	% Deep	% Stings
4 lead, 2 cryolite oil 1% in 2nd-6th	1	6	20,626	94.5	1.7	3.8
4 lead, oil 1% in 2nd-4th	2	5	13,480	89.0	3.6	7.4
10 covers, 1% oil only in each case.	3	6	13,800	84.9	11.9	3.2
Check, no sprays	4	12	26,851	4.8	94.4	0.8

In plot 3 poison was used in the calyx only and the oil sprays were applied about every 7 days. Considering that this plot adjoined the check the results are rather remarkable. The ten applications of oil caused appreciable injury to foliage, especially to Cranberry where it was serious. On McIntosh it appeared as small round dead spots in the leaves; Wealthy showed no foliage injury. Where the crop was at all large the fruit did not size up properly but it was not otherwise injured except the variety Ontario which, at times in the past, has shown fruit injury from even one application of 1% oil. For specifications of oil used see #1 under Oils as Ovicides.

Oils as Ovicides

Small tests with four oils were made on potted apple seedlings sprayed with a DeVilbiss paint gun. The sprays were applied shortly after the eggs were laid (Table 1), and 2 and 4 days before eggs were laid (Table 2). Some specifications of the oils used are given below.

Oils No. 1, 2 and 3 were emulsified with calcium caseinate, 2 oz. per imp. gal.; No. 4 was purchased as a prepared emulsion.

Table I

	1% Oil		1/2% Oil		1/2% Oil plus L. A.*	
Oil	# Eggs	%Mortality	# Eggs	%Mortality	# Eggs	% Mortality
1	1000	98.6	500	99.4	350	87.7
2	774	90.8	579	95.0	500	85.6
3	872	95.1	696	72.4	317	78.3
4	776	94.8	582	70.0	500	91.4
Check	813	2.3				

* Lead arsenate at rate of 1 1/2 lbs. per 40 gal. (Imp.)

Table II

(All oils at 1%)

	2 Days		4 Days	
Oil	# Eggs	% Mortality	# Eggs	% Mortality
1	389	85.1	277	53.1
2	261	77.0	277	46.9
3	213	81.2	350	54.0
4	188	80.3	321	41.1

Checks as in Table I.

Oil Specifications

	#1	#2	#3	#4
Gravity, A.P.I.	36	35/37	28.8 (0.845 sp.gr.)	
Viscosity, 100°F. S.U.	75/85	77/82	77/84	58
U.S.R.	96%	96%	93%	95%
Distillation, 636°F.	8%	8%	32%	55%

DOMINION OF CANADA

Jas. Marshall - Dominion Entomological Laboratory, Vernon, British Columbia.

I. Seasonal Conditions and abundance of the insect during the 1940 season

Unlike 1939, weather conditions in southern British Columbia favoured codling moth development in May and June of 1940. On the other hand, temperatures in August and September were lower than in 1939 and apparently less conducive to serious "second brood" attack. The greater importance of highly favourable conditions during "first brood" attack seems to be reflected in the generally heavier infestation of 1940, despite more careful spraying.

II. Studies on codling moth biology and behaviour

The Calyx spray: Laboratory investigations over a period of three months with six hundred first instar larvae confined individually to an area 5 mm. in diameter in the calyx basin of developing fruits (sprayed only at the calyx period) has provided the following information:

(1) Most of the feeding was done at the outer base of the calyx lobes (sepals), less on the lobes themselves, very little on the pistil and none on the stamens.

(2) About 75 percent of the larvae entered the fruit outside the calyx proper and 25 percent penetrated the calyx lobes to enter the calyx.

(3) There was an average mortality of 81 percent of the larvae that penetrated the calyx lobes of calyx-sprayed fruit and 10 percent of those that penetrated the calyx lobes of unsprayed fruit.

(4) Of the larvae that attempted to enter the fruit outside the calyx lobes, i.e., at the outer base of the calyx lobes, 81 percent mortality resulted on calyx-sprayed fruit, 35 percent mortality on unsprayed fruit.

(5) Mortality of larvae placed on the fruits one month after the calyx spray had been applied was approximately 93 percent on sprayed fruits and 24 percent on unsprayed fruits. Three months after the calyx spray was applied, the mortality was 73 percent on sprayed fruits and 14 percent on unsprayed fruits.

(6) Larvae frequently penetrated the calyx cup proper from within, after having entered the fruit outside the calyx lobes. None of such larvae subsequently died although their operations within the calyx were sometimes extensive. This suggests that poisoning may be unlikely to occur if the codling moth larva consumes apple pulp before ingesting lead arsenate. Other investigations on this point have been under way for two seasons and will be continued.

III. Results of control experiments

(a) Experimental set-up - One block preliminary experiments McIntosh and Jonathan, 20 years, 2 acres. Each plot 3 or 4 trees. Check plots frequently repeated. Second block McIntosh, 30 years, 3 acres, each plot 4 trees. Check plots replicated so that every experimental plot adjoined a check. No calyx spray, three "first brood" covers, one "second brood" cover. Five hundred apples per tree sampled at harvest. No residue analyses.

(b) Conditions affecting the results and control obtained - Orchards both level. Codling moth infestation reasonably uniform and averaging in the check plots, (lead arsenate-casein-lime first brood, cryolite-casein-lime second brood) 10.5 percent.

(d) Injury to foliage and fruit -

(1) Xanthone applied beginning second cover spray caused extensive russetting on Jonathan. It slightly russetted and produced a liver-hued coloration of McIntosh. This condition occurred when xanthone was used with ammonium oleate-zinc sulphate (1 oz. $ZnSO_4$: 100 gal.) and with kerosene-ammonium oleate-zinc sulphate.

(2) Nicotine naphthenate in oil solution (0.5% of 75 Vis., 94% U.R. oil) caused conspicuous black spotting apparently by penetrating lenticels of Jonathan.

(3) "Kolofix" 2.5 lb., caused defoliation when used with 0.5% medium oil (75 Vis., 94% U.R.) and 0.5 pint nicotine sulphate.

(4) Four applications nicotine-sulphate with 0.5% medium oil resulted in distinct injury to calyx of Newtown and to a less extent to calyx of McIntosh.

A. Control by Insecticides

(3) Other Inorganic Materials

1. Natural cryolite ("Kryocide") and synthetic cryolite ("Allorco") gave essentially similar results when used with casein-lime spreader.

2. Cryolite with casein-lime spreader, for the second year gave codling moth control similar to lead arsenate with casein-lime spreader.

3. The addition of one pound hydrated lime to 3.75 pounds cryolite did not reduce the effectiveness of the cryolite. On the contrary it may actually have enhanced it slightly.

4. The addition of 8 pounds brown sugar to 3.75 pounds lead arsenate or cryolite appeared to result in inferior control.

(4) Organic Materials

(a) Fixed Nicotine

1. Bentonite from Drumheller Alberta and Vernon, B.C., gave results comparable to that from Wyoming ("Wyodak" pellet-type).

2. Nicotine sulphate 0.5 pint-medium oil 0.5% gave codling moth control slightly inferior to lead arsenate-casein-lime first brood, cryolite-casein-lime second brood (check).

3. The plot sprayed with "Black Leaf 155" 6 lb. per 100 Imperial gal. (120 U.S.) and 0.5% medium oil was somewhat more heavily infested than the adjoining check plot (10.3% wormy fruit and 7.9% wormy).

4. Nicotine sulphate 0.5 pint-Alberta bentonite 2.5 lb. (dry mixed) - medium oil 0.5% gave control results similar to "Black Leaf 155" 6 lb. with the same amount of oil. Furthermore the residue was as readily removed by wiping at harvest. The same ingredients tank-mixed, as usual produced a residue too tenacious to be removed by wiping.

5. Emulsification of the oil by ammonium oleate in tank-mixed nicotine sulphate-bentonite resulted in a more uniform deposit than when the oil was emulsified only by the nicotine-bentonite complex. The deposit, however, was just as tenacious as when the ammonium oleate was lacking.

6. "Kolofix" when used in place of bentonite in the tank-mixed nicotine sulphate-bentonite-oil mixture resulted in a very spotty deposit that interfered with pigmentation. The same spotty deposit occurred in the absence of oil. Codling moth control with "Kolofix"-nicotine sulphate-oil was apparently slightly inferior to that with bentonite-nicotine sulphate-oil.

7. Nicotine sulphate-Alberta bentonite-Alfalfa flour (dry-mixed) used with oil resulted in codling moth control and residue removal similar to "Black Leaf 155"-oil mixture of equivalent nicotine content.

8. Nicotine alkaloid-Alberta bentonite-Alfalfa flour-ammonium sulphate (dry mixed) used with oil gave control results similar to "Black Leaf 155"-oil mixture of equivalent nicotine content. The residue was as easily removed at harvest.

9. Heavy-medium oil of 75% U.R. was used on a large block of trees in place of heavy-medium oil of 94% U.R. in two second brood applications of nicotine-bentonite mixture without sign of injury to Delicious or Jonathan. The former oil is about half as expensive as the latter.

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RESULTS OF CODLING MOTH INVESTIGATIONS, 1940

Part II

Work Conducted by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture

Not for Publication

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RESULTS OF CODLING MOTH INVESTIGATIONS, 1940

Part II

Work Conducted by the Bureau of Entomology
and Plant Quarantine,
U. S. Department of Agriculture.

This summary represents the contribution of the Division of Fruit Insect Investigations of the Bureau of Entomology and Plant Quarantine to the pool of information on the results of codling moth investigations carried on during 1940, which has been prepared in accordance with a request made by the Committee on the Codling Moth of the American Association of Economic Entomologists. As in previous years, this is a preliminary report, circulated for the information of those interested. It is subject to revision as further review of the date may indicate, and has the status of unpublished data, not subject to quotation without permission.

The work of the Division of Fruit Insect Investigations is carried on cooperatively with several Bureau and Department units, as well as with a number of State agencies. The Division of Insecticide Investigations has contributed a great deal to the work reported herein, and joint field laboratories are maintained at Yakima, Washington, and Vincennes, Indiana. The chemists stationed at the latter laboratory have also participated to a considerable extent in the work at St. Joseph, Mo. The work in West Virginia is a joint effort carried on by the West Virginia Agricultural Experiment Station and this Bureau; the work in New York State is carried on similarly with the New York Agricultural Experiment Stations.

The Division of Foreign Parasite Introduction has continued to cooperate in the work relating to parasites. Special attention has been devoted to certain phases of the biological-mechanical control project under way in West Virginia.

POUGHKEEPSIE, NEW YORK

P. J. Chapman, In General Charge
D. W. Hamilton, In Immediate Charge

Seasonal Developments

Mortality of overwintering codling moth larvae as determined from the examination of 2210 larvae and pupae overwintering under paper bands was low for the winter of 1939-40. Counts of larvae under bands in three different orchards in the Hudson River Valley during May averaged 8.4, 8.1, and 16.0 percent dead.

Adult codling moths began appearing in bait traps May 26, exactly 22 days after the first pupa was found. This was a few days later than normal (May 23-25). Tree development was delayed because of low spring temperatures. Only a very few moths were captured in bait traps during May. Weather conditions during June and July were favorable for codling moth development. This, combined with the heavy carry over of larvae from 1939, caused bait traps to record the heaviest flight of moths during this period of any season on record. Records are from 10 bait traps located in the same trees since 1936. Peak moth captures occurred June 3 to 8, and June 13 to 14, with a steady but comparatively high daily average July 6 to 15, for first brood. Second brood captures showed slight peaks August 3 to 4, and August 12 to 14. The total moth capture for the season in 10 bait traps was 2607 moths, as compared to 937 moths for 1939. Eighty-six percent of the moths captured were taken during June. The amount of first brood injury as determined by observations in orchards receiving no sprays, or only light applications, was more severe than usual. Second brood captures, while not as heavy as in 1939, were large enough so that oviposition was abundant, which, combined with favorable weather conditions, caused serious injury to occur during August and early September in orchards where poor control occurred during first brood.

Larvae began entering the fruit about June 10. New entrances were readily found by June 12. As determined by the removal of all apples containing injuries on two unsprayed trees at approximately 7 to 10 day intervals, first brood larval entrances were plentiful for the weeks ending June 15 to June 29, amounting to 19.2 percent of the total injury for the season. From June 29 to the middle of July the number of new entrances tapered off, entrances removed amounting to only 3.2 percent of the total infestation. A distinct increase in the number of new entrances was noticed for the weeks ending July 17 through July 26, entrances removed amounting to 22.3 percent of the seasons total. This increase in late first brood entrances, that is July 17 to 26, does not normally occur and in some orchards a special cover spray was necessary to protect the fruit against injury during this period. During second brood activity new entrances began increasing in number for the week ending August 5, and continued abundant through the week ending August 29. As a whole codling moth injury for 1940 continued to be severe (from 15 to 50 percent of the total crop injured) in orchards having heavy codling moth populations in 1939, except where thorough spray programs, much more efficient than those resulting in effective control for this locality 5 to 10 years ago, properly timed and applied were used.

Some of the meteorological data, codling moth captures in the 10 sassafras-brown sugar traps, and injuries from 2 unsprayed McIntosh trees, are presented in table 1.

Table 1. Meteorological Data, and Codling Moth Bait-Trap Captures. Poughkeepsie, N. Y., 1940

	May	June	July	Aug.	Sept.	Season
Mean daily temperature	57.0	65.5	71.0	70.6	59.8	64.8
Precipitation (inches)	5.46	3.42	4.86	5.58	4.06	23.38
No. days rain occurred	18	14	14	11	7	64
Moth captures - 10 traps	13	2243	240	101	10	2607
Injuries - 2 trees*		679	710	314	90	1793

*Since all injured apples were removed at 7 to 10 day intervals figures for August and September are lower than normal because of the smaller number of apples present.

Insecticide Experiments

Tests of insecticides and orchard spray schedules consisted of 5 blocks at Poughkeepsie, and one block at Kinderhook. Materials tested were those considered having possibilities against heavy codling moth infestations, without creating objectionable harvest residues. Excessive residues of lead and arsenic, and visible deposits of such materials as bentonite and lime were among those considered as objectionable. Preferential consideration was also made in many instances by the inclusion of materials and schedules that were known to be effective against apple fruitfly as well as codling moth.

Tests at Poughkeepsie:-

Blocks 1-4 consisted of a corner of a mature Cortland orchard that has one of the heaviest codling moth infestations in this locality. While adjacent to each other within the orchard, each block was arranged as a separate experiment.

Block 1:- This series consisted of 6 treatments on 2 tree plots replicated 4 times, and 2 treatments on single tree plots replicated 2 times. Materials compared were those considered desirable for so called split schedules where arsenicals are used for protection during first brood and other materials are used for control during second brood. Advantages of such schedules are that the arsenicals present aid in apple fruitfly control, less costly materials are used than in straight schedules other than arsenicals, and materials used are compatible with sulfurs used as fungicides during early first brood.

Spray treatments and results are presented in Table 2.

Table 2. Spray Schedules Used and Results - Codling Moth Control - Block 1. Poughkeepsie, N.Y., 1940, Var. Cortland.

Block 1. Comparison of 2nd. brood sprays following a light arsehical 1st. brood schedule.

Materials per 100 Gallons

First Brood Spray Schedule: All plots except 8.
Curculio Spray; June 5; lead ars. 3 lbs.; hyd-lime 3 lbs; Micronized dusting sulfur 4 lbs.; pwd. skim milk 0.25 lb..
1st. Cover; June 13-14; lead ars. 3 lbs.; hyd-lime 3 lbs.; Micronized dusting sulfur 3 lbs.; pwd. skim milk 0.25 lb..
2nd. Cover; June 27; calcium ars. 3 lbs.; 0.75 - 6 - 100 bordeaux; pwd. skim milk 0.25 lb..
3rd. Cover; July 11; same as 2nd. cover.

Second Brood Spray Schedules: 2 applications, August 7 and 12.
Plot 1: No spray applied.
Plot 2: Proc. nicotine-bentonite* 4 lbs.; summer oil (com. 83% oil) 0.6 percent actual oil.
Plot 3: Proc. nicotine-bentonite* 4 lbs.; summer emulsible oil (2% oil sol. emulsifying agent, 62 vis.,0.2% deposit builder) 0.6 percent actual oil.
Plot 4: Proc. nicotine-bentonite* 4 lbs.; summer oil 0.6 percent actual oil; blood albumen emulsifier 0.5 lb..
Plot 5: Proc. nicotine-bentonite* 4 lbs.; nicotine sulfate 0.5 pt..
Plot 6: Xanthone 2 lbs.; sodium oleate soap 1 lb.; zinc sulfate (monohydrated) 4.5 ozs..
Plot 7:**Proc. nicotine-bentonite* 4 lbs.; free phytonomic oil (sp. gr. 820-830, vis. 55-60, unsulf. residue 99-100%) 0.6 percent actual oil; blood albumen emulsifier 0.5 lb..
Plot 8:**Growers schedule; combined light arsenicals followed by processed nicotine and oil. Applications made by grower.

Infestation Records

Plot No.	Apples Per Tree	Injuries per 100 Apples		Apples clean percent
		Worm Holes	Stings	
1.	1401	71.9	34.7	55.8
2.	1352	19.3	23.5	73.9
3.	1689	24.6	22.6	71.1
4.	1185	16.0	20.0	77.4
5.	1203	31.3	22.8	72.1
6.	1316	15.7	30.6	72.3
7.**	2136	32.2	28.3	66.4
8.**	1644	54.6	41.0	54.3

* Nicotine content according to manufacturer 4.75 percent.
** Two trees only.

While analysis of variance was not made, it seems obvious that all experimental schedules used during second brood were superior to no sprays at all and the growers schedule, plots 1 and 8. A comparison of 4 different summer oils (plots 2,3,4, and 7 with proc. nicotine-bentonite, indicated that a commercial oil (plot 4) tank mixed with blood albumen gave better control than the other 3 oils tested including one widely used factory emulsion. Differences between the other 3 oils tested did not appear to be significant. Xanthone (plot 6) when used during second brood had the least number of worm holes per 100 apples of any of the materials tested, and with the exception of plots 4 and 2 seemed more effective than other schedules tested. Advantages of the use of xanthone over other materials ~~tested~~ for second brood control if tests continue to show that it is effective are, its compatibility with sulfur, and the fact that lime does not effect its toxicity so that hydrated lime and arsenicals can be mixed with it in light dosages for late apple fruitfly control. It should be pointed out that the characteristic injury occurring in the form of a russetted ring around the calyx end of the apples on plots where xanthone was used throughout the season (Plot 14 -Bl. 2) was only present on a small percentage of the apples. When present this russeting was barely visible and probably not of commercial importance. A careful count showed less than 0.3 percent of the fruit affected.

Block 2: In this series 10 different spray schedules considered as having possibilities for controlling heavy codling moth infestations and at the same time avoid objectionable residues at harvest (excepting plot 11) were compared. Plots 11, 12, 15, 17, and 18 were considered as having arsenicals present in large enough quantities to be effective against moderate infestations of apple fruitfly as well as controlling codling moth. The 5th cover in plot 12 and the zinc arsenate in plot 18 were included in the schedules for their effects on fruitfly. See report on apple fruitfly by O. H. Hammer. Two tree plots replicated 4 times were used. Trees used for this series were the same as those used for the tests in table 1 of the 1939 report. The crop was considerably lighter in 1940. Treatments and results are presented in table 3.

Table 3. Spray schedules. Block 2. Variety: Cortland

Abbreviations. L.A. = lead arsenate; Lime = hydrated spray lime; Milk = powdered skim milk, .25 lb; C.A. = calcium arsenate; Nic.Sul.= nicotine sulfate 40%; Oil = summer oil (33%); N.B.= factory processed nicotine bentonite Percent nicotine in parenthesis; Bord.= 0.75-6-100 bordeaux mixture; Sulfur = micronized dusting sulfur; Z.A. = zinc arsenate; Xanthone = 2 lbs. + sodium oleate 1 lb. zinc sulfate 4.5 oz.

Quantities are for 100 gals.

Note. All plots received a curculio spray of L.A. 3 lbs., Lime 3 lbs., Sulfur 4 lbs. and Milk on June 5. Plot 12 was given a special spray of C.A. 3 lbs., Bordo. and Milk on July 22.

Plot	1st cover (6/13-14)	2nd cover (6/26-27)	3rd cover (7/5-6)	4th cover (7/15)	5th cover (8/6)	6th cover (8/17)
11	L.A.3 Lbs.,Lime 3 lb: Sulfur 3 lbs.,Milk	L.A.3 lbs.,Lime 3 lbs. Milk	As in 2nd cover	As in 2nd cover	As in 2nd cover	As in 2nd cover
12	Same as Plot 11	L.A.1.5 lb.,C.A.1.5 lb. Bord.Milk,Nic.Sul..5 pt	N.B.(4.75)4 lb. Oil 3 qts.	As in 3rd cover	N.B.(4.75)4 lb. Oil 2 qts.	As in 5th cover
13	L.A.3 lbs.Bord Milk	N.B.(4.75)4 lb.Oil 3 qts	Same as Plot 12	Same as Plot 12	Same as Plot 12	Same as Plot 12
14	Xanthone,Sulfur 3 lbs	Xanthone	Xanthone	Xanthone	Xanthone	Xanthone
15	Same as Plot 11	Same as Plot 11	C.A.3 lbs.,Bord. Milk	Unsprayed	Same as Plot 12	Same as Plot 12
16	Same as Plot 11	Same as Plot 12	N.B.(2.8)4 lbs. Oil 3 qts.	As in 3rd cover	N.B.(2.8)4 lbs. Oil 2 qts.	As in 5th cover
17	Copper arsenate 3 lbs: Lime 3 lbs.,Sulfur, Milk	Copper ars.3.1bs.Lime 3 lbs.,Milk	As in 2nd cover	As in 2nd cover	As in 2nd cover	As in 2nd cover
18	Same as Plot 11	N.B.(14)3 lbs.,Z.A.2 lbs.,Lime 0.5 lb.Sulfur 4 lbs. Milk	N.B.(14)3 lbs.,Z.A.2lbs.Lime 1 lb.,Sulfur,Milk	N.B.(14) 3 lbs. Z.A. 2 lb.Lime 0.5 lb.	N.B.(14) 3 lbs.	N.B.(14) 3 lbs.
19	Same as Plot 13	N.B.(14)1.5 lbs. Oil 2 qt	As in 2nd cover	As in 2nd cover	As in 2nd cover	As in 2nd cover
20	Same as Plot 11	N.B.(14) 3 lbs.,Benton-ite 1 lb.	As in 2nd cover	As in 2nd cover	Same as Plot 19	Same as Plot 19

Infestation Records

Table 3 (continued)

Plot No.	Apples Per Tree	Injuries per 100 apples		Apples Clean
		Worm Holes	Stings	percent
11.	1803	1.1	7.9	91.2
12.	1813	4.2	8.7	87.9
13.	1774	6.5	7.9	86.3
14.	1958	6.4	6.1	88.4
15.	2059	5.0	10.6	85.9
16.	2130	8.0	9.0	84.6
17.	2111	7.5	19.1	73.7
18.	1839	3.1	8.0	87.8
19.	1867	7.5	8.1	85.8
20.	1916	6.7	9.1	85.1

As indicated by the percent clean fruit, four cover sprays timed at approximately 10 day intervals during first brood are more effective than the three covers formerly used over the same period. Six covers of lead arsenate (plot 11) was the most effective spray schedule used. Of course residues of lead and arsenic from this plot exceeded the tolerances at harvest, and it is obvious that such a schedule is unsatisfactory in a non-wash region. Plots 12, 13, 14, 18, and possibly 15, are considered as having given comparatively high control when compared to the rest of the plots in the block. Of these plots 12 and 13 showed evidences of bentonite on the fruit at harvest. While the amount of bentonite residue present was not large, it was more than that present on plots 16 and 19 and was enough to be considered objectionable by certain growers, who have apples on the market competing with those of lightly sprayed trees from orchards where codling moth control is not a serious problem. Plot 14 had almost 45 percent of the fruit russetted around the calyx end. As demonstrated in plot 6, block 1, this injury is not severe where xanthone is used later in the season; consequently this material has possibilities of becoming a follow-up spray in arsenical-xanthone schedules. Plot 18 showed foliage burning and early drop of fruit, presumably due to the presence of the basic zinc arsenate with only a small quantity of lime. Plot 15 had good control considering that only 3 sprays were applied during first brood. Lead arsenate could be substituted for the calcium arsenate used in the third cover spray without exceeding the new residue tolerances, and thus increase the efficiency of this schedule. Plots 16, 19, and 20, while not considered to be as effective as some of the other schedules used gave good control. The fruit from plot 16 had the best finish with less visible residue on it of any of the nicotine programs in the block. Better control would have been secured in this plot if nicotine sulfate had been added to the processed nicotine. Processed nicotine-bentonite concentrate when used with summer oil (plot 20) seemed to be as effective as when used double strength with Wyoming bentonite added during the first brood (plot 19). Plot 20 had very little visible residue on the fruit at harvest and would probably meet commercial requirements. Plot 17 was not outstanding from the control viewpoint and in addition 22 percent of the apples were russetted as compared to 4 percent for plot 11.

Block 3: This series of plots was of an exploratory nature and consisted of field tests with 2 types of rapeseed oil and various nicotines for the purpose of determining their effects on foliage and fruit as well as the codling moth control obtained. All tests were in cooperation with R. T. Hansberry and L. B. Norton of Cornell University and the New York Agricultural Experiment Station. The materials used were suggested by them. Plots consisted of single tree plots replicated twice.

Nicotine peat left a heavy black residue and processed nicotine-bentonite concentrate was substituted for it later in the season. Rapeseed oil was used with sulfur on a few trees during first brood and only caused slight foliage burn. A commercial oil emulsion applied at the same time with sulfur caused severe burning. Materials used, dosages, dates of application, and a summary of infestation records are presented in table 4. Infestation records from the more generally used schedules in blocks 1 and 2 have been included in the series for comparison. Data for schedules from Blocks 1 and 2 are compiled from the 2 trees closest to block 3.

Table 4. Spray Schedules Used and Results - Codling Moth Control - Block 3
Poughkeepsie, N.Y., 1940, Var. Cortland

Block 3: Comparison of Vegetable Oils and Various Nicotines not Previously Used.

Materials per 100 Gallons

Plots 21-24: Curculio spray, June 5, lead ars. 3 lbs., hyd-lime 3 lbs., Micronized dusting sulfur 4 lbs., pwd. skim milk 0.25 lb.; 1st. cover, June 13-14, lead ars. 3 lbs., 0.75-6-100 bordeaux, pwd. skim milk 0.25 lb..

Plot 21: Nicotine pectate 1.4 qts., applied June 27, July 6, July 16, Aug. 8, and Aug. 19.

Plot 22: Nicotine oleate 1.2 pts., rapeseed oil emulsion 2.5 qts., applied June 27, July 6, July 16, Aug. 8, and Aug. 19.

Plot 23: Nicotine peat 8 lbs., rapeseed oil emulsion 2.5 qts., applied June 27, and July 6; Proc. nicotine-bentonite conc.* 1.5 lbs., rapeseed oil emulsion 2.5 qts., applied July 16, Aug. 8, and Aug. 19.

Plot 24: Nicotine peat 8 lbs., blown rapeseed oil 1 pt., applied June 27, and July 6.; proc. nicotine-bentonite conc* 1.5 lb., blown rapeseed oil 2.5 qts., applied July 16, Aug. 8, and Aug. 19.

Plots 1 & 8: Parts of block 1. See table 2 for spray schedules.

Plots 11, 13, & 19: Parts of block 2. See table 3 for spray schedules.

* Nicotine content according to manufacturer, 14 percent.

Infestation Records

Plot No.	Apples Per Tree	Injuries per 100 Apples		Apples Clean
		Worm Holes	Stings	percent
21.	1749	44.2	18.2	66.4
22.	2614	19.7	11.4	80.4
23.	2083	5.2	6.2	91.4
24.	2210	13.7	12.3	82.2
1.	1756	62.5	28.5	61.1
8.	1644	54.6	41.0	54.3
11.	1521	1.9	7.8	92.0
13.	1292	5.7	9.2	88.6
19.	2195	11.2	9.3	86.6

Block 4: In this series preliminary field tests were made for the comparison of a commercial calcium arsenate with laboratory calcium arsenate and laboratory prepared zinc arsenate. These experiments were in cooperation with G. W. Pearce and A. W. Avens, Division of Chemistry, New York Agricultural Experiment Station. The laboratory materials were prepared by them.

Five cover sprays during the season on single tree plots replicated twice had 65.1 percent clean fruit for the commercial calcium arsenate, 45.5 percent for the laboratory calcium arsenate, and 43.6 percent for the laboratory zinc arsenate. Plot numbers were 25, 26, and 27.

Block 5: This block consisted of a semi-isolated orchard of Cortland and McIntosh trees. The block had 189 trees in it. At least 30 percent codling moth injury was present in 1939.

A so called "double action" spray program directed at both the adult and larval stages of the codling moth was used in this planting. Since the object was to annihilate the first brood codling moth to such an extent that spraying for second brood control would be unnecessary no second brood sprays were planned. However, bait-trap captures and daily observations on larval entrances during second brood indicated that at least one second brood spray would be desirable and a delayed application was made on all but one sub-block. The orchard was arranged in sub-blocks so that comparisons could be made on slight variations in the spray schedule as conditions warranted. Dusts were applied for the control of a light fruitfly infestation and for comparing foliage injury on such a combined spray and dust program.

While first brood codling moth injury was not annihilated completely it was effectively reduced so that second brood injury was not as serious as it had been in previous years. Codling moth injury in this orchard was much lighter than it was in a similar orchard about one fourth mile distant operated by the same grower and ordinarily having about the same amount of codling

moth injury present (Sub-block 5E, table 5). Since the second brood spray was delayed until new entrances were numerous, better control would have been obtained with the same schedules by careful timing of the second brood application. The use of lead arsenate in more of the first brood sprays, with nicotine sulfate when hatching is heavy and when adult moths are plentiful, would also tend to increase the efficiency of first brood applications. Such a change would be possible with the recent tolerances for arsenic and lead. The amount of lead arsenate used for first brood was limited at the time of the experiment as a part of the object was the avoidance of objectionable residues at harvest under the former tolerances. Materials, dosages, dates of application, and a summary of infestation records are presented in table 5.

Table 5. Spray Schedules Used and Results - Codling Moth Control - Block 5. Poughkeepsie, N.Y., 1940, Var's Cortland and McIntosh

Materials per 100 Gallons

Calyx Spray: Sub-blocks 5A, 5B, 5C, May 29, lead ars. 3 lbs., hyd-lime 3 lbs., dry lime-sulfur 6.25 lbs.; Sub-block 5D, May 28, lead ars. 3 lbs., hyd-lime 3 lbs., Micronized dusting sulfur 4 lbs., Com. oil sticker 1 pt..

Sub-Blocks 5A, 5B, 5C, 5D: Curculio spray, June 6, lead ars. 3 lbs., hyd-lime 3 lbs., Micronized dusting sulfur 4 lbs., pwd. skim milk 0.25 lb.; 1st. cover, June 14, lead ars. 3 lbs., hyd-lime 3 lbs., nicotine sulfate 0.5 pt., Micronized dusting sulfur 3 lbs., pwd. skim milk 0.25 lb.; 2nd. cover, June 25, lead ars. 1.5 lb., calcium ars. 1.5 lb., 0.75-6-100 bordeaux, nicotine sulfate 0.5 pt., pwd. skim milk 0.25 lb.; 3rd. cover, July 3, proc. nicotine-bentonite* 4 lbs., summer oil 3 qts.; 1st. dust, July 6, calcium ars. 15 percent, hyd-lime 85 percent.

Sub-Blocks 5A, 5B, 5C; 4th. cover, July 15, nicotine sulfate 0.5 pt., summer oil 3 qts..
Sub-Blocks 5D: 4th. cover, July 15, proc. nicotine-bentonite* 4 lbs., summer oil 3 qts..

Sub-Blocks 5A, 5B, 5C, 5D: 2nd. dust, July 25, calcium ars. 15%, hyd-lime 85%.

Sub-Block 5A; Delayed 2nd. br., Aug. 12, proc. nicotine-bentonite conc.** 3 lbs.;
Sub-Blocks 5B, 5D: Delayed 2nd. br., Aug. 12, proc. nicotine-bentonite conc.** 1.5 lb., summer oil 2 qts..
Sub-Block 5C: Delayed 2nd. br., Aug. 12, No spray applied.

Sub-Block 5E: Schedule applied by grower in an orchard one-fourth mile distant that had about the same initial infestation as the annihilation blocks. Schedule consisted of arsenical sprays early part of season followed by proc. nicotine and oil later in the season.

* Nicotine content according to manufacturer 4.75 percent.
** Nicotine content according to manufacturer 14 percent.
Summer oil used 83 percent actual oil.

Infestation Records

Block No.	Variety	Apples Per Tree	Injuries Per 100 Apples		Apples Clean
			Worm Holes	Stings	percent
5A.	Cortland	1390	9.4	12.8	82.9
5B.	Cortland	1525	5.1	16.6	83.3
	McIntosh	1713	4.5	11.1	86.2
	Both	1619	4.8	13.8	84.8
5C.	Cortland	1257	20.9	21.4	76.7
	McIntosh	831	8.4	8.5	87.0
	Both	1115	16.7	17.1	80.1
5D.	Cortland	1230	7.3	15.4	83.9
	McIntosh	1012	8.7	10.1	85.5
	Both	1157	7.8	13.6	84.4
5E.	Cortland	1422	67.1	26.1	53.4

Tests at Kinderhook:-

The object of this test was to demonstrate a practical combined arsenical and nicotine spray schedule that would be compatible with sulfur fungicides early in the season and at the same time control the heavy infestation of codling moth present.

Block 6: This block consisted of 74 McIntosh trees. The 1939 crop was severely damaged by codling moth and was almost a complete loss. Calyx and curculio sprays were applied by the grower. Each spray contained 3 pounds of lead arsenate for 100 gallons of spray.

The effect of summer oil applied at too short an interval following a spray containing sulfur was demonstrated by using 2 pounds of Micronized dusting sulfur for 100 gallons of spray on one-half the block in the second cover spray applied June 21, and using 3 quarts of summer oil in the third cover spray applied July 1. Injury to the foliage in the form of brown spots in the leaves and a yellowing and dropping of some of the leaves occurred where sulfur was applied in the 2nd cover spray. Drop fruit counted August 2 averaged 26.4 percent of the crop on the sulfur followed by oil trees; as compared to 6.2 percent of the crop on trees not receiving sulfur in the second cover but sprayed with oil in the third cover spray.

Certain variations were made in the spray schedule on different sub-blocks at the time of the 5th cover spray. This spray is not usually applied in this locality and was made necessary because of the increase in the number of late first brood entrances discussed under seasonal developments.

Schedules used and dates of application are shown in table 6.

Table 6. Spray Schedules Used and Results. Codling Moth Control Block 6. Kinderhook, N. Y. 1940. Variety, McIntosh.

Materials per 100 gals.

Sub-Blocks 6-1, 6-2, 6-3, 6-4, 6-5. Sprayed alike except for 5th cover.

1st cover. 6/12: Lead ars. 3 lbs., lime 3 lbs., micr. dusting sulfur 3 lbs., soybean flour 0.5 lb.

2nd cover. 6/21: Lead ars. 1.5 lbs., calcium ars. 1.5 lbs., 0.75-4-100 bordeaux, nicotine sulfate 1 pt., powd. skim milk 0.25 lb. One-half of each block had micr. sulfur, 2 lbs. added.

3rd cover. 7/1: Proc. Nic. bent.* 4 lbs., summer oil 3 qts.

4th cover. 7/9: " " " " " " " " "

5th cover. 7/19: See table below.

6th cover. 8/6: Proc. Nic. bent.* 4lbs., summer oil 2 qts.

7th cover. 8/16: " " " ** 1.5 lbs., " " " "

Sub-Block 6-6. Arsenical schedule during early first brood followed by nicotine and oil later in the season, applied by grower.

Infestation records

Sub-Block No.	5th cover spray treatment	Apples per tree	Injuries per 100 apples: Worms	Injuries per 100 apples: Stings	Apples clean percent
6-1	Nic.sul.0.5 pt.,summer oil 3 qts.	1127	11.2	14.6	80.2
6-2	Nic.sul.0.5 pt.,summer oil 3 qts. lime 0.5 lb.	1321	9.5	14.7	81.4
6-3	No spray applied	2563	16.7	17.7	75.6
6-4	Zinc.ars.2 lbs.,lime 2 lbs.,nic. sul.0.5 pt.,pwd.milk 0.25 lb.	1460	10.0	14.1	80.9
6-5	Zinc ars. 2 lbs., lime 2 lbs., pwd. milk 0.25 lb.	1798	11.1	21.3	78.5
6-6	Sprayed by grower	1972	35.9	19.7	66.3

* Nicotine content according to manufacturer 4.75 percent.
** Nicotine content according to manufacturer 14 percent.
Summer oil used contained 83 percent actual oil.

Harvest Residues of Lead and Arsenic:-

A large number of the plots in blocks 1 and 2 had residues at harvest above the tolerances of 0.01 grains per pound of fruit for arsenic. However, with the exceptions of plots 11 and 17 where arsenicals were used throughout the season, residues were below the new tolerances of 0.025 grains of arsenic per pound of fruit. Plots in block 4 exceeded the new tolerance of 0.025 grains of arsenic per pound of fruit. Brushing the fruit, by running it through a grader containing brushes, from plots 11, 17, and 25 reduced the amount of arsenic present but did not bring it within the new tolerance. Residues present at harvest on plots most likely to exceed tolerances are shown in table 7. Samples were taken by reaching into the trees from the ground.

Table 7. Harvest Residues of Lead and Arsenic* - 1940 -

Block**	Plot**	Variety	Harvest Residues (grains per lb.)	
			AS_2O_3	Pb.
1	1	Cortland	0.018	0.016
2	11	Cortland	0.071	0.183
2	11 brushed	Cortland	0.037	0.095
2	12	Cortland	0.015	0.020
2	15	Cortland	0.017	0.028
2	16	Cortland	0.012	0.023
2	17	Cortland	0.042	0.008
2	17 brushed	Cortland	0.032	0.008
4	25	Cortland	0.052	0.007
4	25 brushed	Cortland	0.029	0.005
4	26	Cortland	0.042	0.006
4	27	Cortland	0.039	0.006
5	5B	Cortland	0.010	0.020
6	6-1	McIntosh	0.010	0.021
6	6-5	McIntosh	0.016	0.019

* Analyses by G. W. Pearce and A. W. Avens, Dept. of Chemistry, New York Agricultural Experiment Station.
** For spray schedules see tables 2, 3, and 6, and text under block 4.

Effect of Change in Tolerances on Amounts of Lead Arsenate that Can Be Used In This Region Without Washing:-

The increase in the tolerances of arsenic to 0.025 grains and lead to 0.05 grains per pound of fruit should in most instances allow 3 cover sprays of lead arsenate at 3 pounds per 100 gallons to be used without necessitating cleaning of the fruit; whereas previously 1 cover of lead arsenate followed by 2 covers of calcium or basic zinc arsenates was considered to be on the margin. As indicated in table 8, three covers of lead arsenate does not always control codling moth adequately, unless followed by other materials such as nicotine-bentonite and oil.

Table 8. Residues at Harvest and Infestation Records - 3 Cover Sprays Lead Arsenate - 1936 to 1938.

Year-Variety	Apples Per Tree	Injuries Per 100 Apples		Apples Clean	Harvest Residues* gr./lb.	
		Worm Holes	Stings	Percent	AS_2O_3	Pb.
1936 McIntosh	1919	16.8	20.0	74.5	0.028	0.060
1937 McIntosh	1538	10.2	25.9	75.9	0.020	0.046
1938 Cortland	1178	5.8	13.2	87.2	0.009	0.031

* Analyses by G. W. Pearce and A. W. Avens, Dept. of Chemistry, New York Agricultural Experiment Station.

Band Experiments

The large scale band experiment at Kinderhook, was continued for a third year. Plot arrangements and methods were identical with those reported in 1939. The number of trees banded was 465.

A very effective arsenical-nicotine oil spray schedule (consisting of 2 covers lead arsenate with nicotine sulfate, 2 covers proc. nicotine and nicotine sulfate, with oil, and one cover nicotine sulfate and oil), along with increased gallonage, and more thorough spraying, applied by the grower were primarily responsible for the big reduction in the infestation of both the banded and unbanded areas in 1940.

Larvae captured in bands averaged less than one per tree for all varieties. The 465 trees captured 290 larvae during the season. In the banded area better than 96 percent of the fruit (based on an unweighted average of all varieties) was clean; as compared to 92 percent of the fruit in the non-banded area. Efficiency based on Abbott's formula has increased in the banded area over that of the non-banded area for each of the three years the band experiment has been operated. For the Duchess and McIntosh blocks the increase in efficiency due to bands averaged 46.7 percent in 1938, 54.4 percent in 1939, and 67.2 percent in 1940; or an increase of 7.6 percent the second year over that of the first, and 12.7 percent in the third year over that of the second. By the end of the third year efficiency had increased 20.4 percent in the banded area over that at the end of the first year of banding.

Infestation records for 1940 are presented in table 9.

Table 9. Results of Large Scale Band Experiment, Kinderhook, N. Y., 1940.

Variety	Apples per Tree		Worm Holes per 100 Apples		Stings per 100 Apples		Percent of Apples Clean		Injuries per Tree	
	Banded	Unbanded	Banded	Unbanded	Banded	Unbanded	Banded	Unbanded	Banded	Unbanded
Duchess	3034	2583	0.4	2.2	0.6	3.3	99.1	95.2	32	141
McIntosh (large trees)	2735	2686	3.4	8.4	1.7	6.4	96.1	88.8	133	397
McIntosh (ave. trees)	1292	1537	1.8	5.8	1.3	4.0	97.4	92.4	39	152
McIntosh (ave. trees)	1083	1050	2.6	5.0	1.8	5.1	96.6	91.9	50	103
Greening (young trees)	747	443	4.8	4.1	5.9	5.7	91.3	92.2	84	42
All Varieties Ave.	1778	1660	2.6	5.1	2.3	4.9	96.1	92.1	68	167

Table 10 shows the estimated bushels of apples saved per tree as a result of the scraping and banding. It costs between 20 and 24 cents a tree each year to scrape and band.

Table 10. Estimated Number of Bushels of Apples Saved Per Tree by Scraping and Banding. Based on 125 apples per bushel. Kinderhook, N.Y. 1938-40.

Variety	1938	1939	1940
Duchess	1.7	2.6	0.9
McIntosh (Large trees)	2.5	9.3	1.6
McIntosh (ave. trees)	0.7	3.0	0.5
Greening (Young trees)		1.0	0.0

Bait Trap Experiments

Comparisons of bait trap solutions were made in two series of traps arranged in modified Latin-squares, consisting of 5 traps each replicated 5 times. One trap was used per each tree. Baits were changed at approximately 20 day intervals unless otherwise stated. The twin type of trap was used whereby half-trap bait changes were alternated at ten day intervals. Results are presented in table 11.

From table 11 it appears that oil sassafras and oil mace were the best attrahents tested with the brown sugar solution in this locality. The addition of a half gram of sodium benzoate to the bait after fermentation was well started prolonged the length of time such baits are effective so that changes were probably necessary only twice a season instead of every 20 days as heretofore. The use of ceramic blocks impregnated with oil sassafras increased the duration of time the aromatics were effective. Bromstyrol while less effective as an

attrahent than oil sassafras showed some tendencies toward superiority during the real hot weather indicating that it is more of a hot weather bait. It should be recalled that during the hot-dry season of 1939 bromstyrol was more effective as an attrahent than oil sassafras.

Table 11. Bait Trap Captures - Latin Square Arrangements - Poughkeepsie, N.Y. 1940

Bait	Composition	Total No. Moths Captured		
		May-June	July-Aug.	Season
	Series 1.			
A-	Oil sassafras, in B.S. sol.	489	113	602
B-	Bromstyrol, in B.S. sol.	462	157	619
C-	Anethol, in B.S. sol.	349	77	426
D-	Oil mace, in B.S. sol.	492	182	673
E.1-	Oil pine, in B.S. sol.	164	discontinued.	
E.2-	Oil sassafras, in B.S. sol.; sassafras in impregnated clay blocks. 0.5 gr. sodium benzoate added to each half-trap after fermentation was well along (10 days after filling). Bait unchanged after put out.	Not out.	162	
	Series 2.			
A-	Oil sassafras, in B.S. sol.	586	165	751
B-	Oil sassafras, in B.S. sol.; 0.5 gr. sodium benzoate added to each half-trap 10 days after traps were filled. Bait unchanged during the season.	726	88	814
C-	Oil sassafras, in B.S. sol.; 1 gr. sodium benzoate added to each half-trap 10 days after traps were filled. Bait unchanged during the season.	481	34	515
D-	Oil sassafras and nicotine sulfate, in B.S.sol.	581	142	723
E-	Bromstyrol, in B.S. sol.	428	111	539

B.S. sol. consisted of 5 pounds No. 13 brown sugar in water to make 5 gallons. A small quantity of Dreft was added to reduce surface tension. Aromatics were added to baits with a dropping bottle using 0.5 cc. per each half-trap, except bait E., series 1.

Fumigation of Prop Poles for Killing Hibernating Codling Moth.

Tests conducted in 1940 indicated that 2 pounds of sodium cyanide in the acid-pot method were necessary for each 1000 cubic feet of space used instead of the 1 pound found effective in 1939. Poles were stacked in "wigwam" fashion and covered with truck tarpaulins. The 2 pounds of cyanide killed 97.5 percent of the larvae but only 79.4 percent of the pupae. Most of the larvae and pupae not killed were near the centers of the pile.

Dormant Larvicides for Killing Hibernating Codling Moth.

Preliminary tests using larvicides that were thought to be penetrative enough to pass through the cocoons and kill the larvae overwintering under the bark of the trees were applied May 17. In order to have a large number of larvae present on a small area, materials were applied to the trunks of trees on places where overwintering paper bands had caused a large number of larvae to be concentrated. All larvae whose cocoons were disturbed by the removal of the bands were removed from the tree trunks before treatment. Since the larvae used had been under paper bands some of them were not imbedded in the bark as deeply as they would have been normally, and some may have been more easily killed.

Materials were applied by brushing the larvicides on the tree trunks and by using a small hand sprayer of the atomizing type. The pine tar oil mixture was thick and it was difficult to apply with the atomizer. Mortality counts were made May 21 and 22. Three trees were used for each treatment.

Pine tar oil 378.7 cc., oleic acid 62.3 cc., triethanolamine 32 cc., and water 488 cc., killed 74.1 percent of the larvae and pupae when brushed on the tree trunk, and 16.9 percent when applied with the atomizer.

Pyrethrin concentrate No. 20, 1 part; and deodorized kerosene, 92-94 percent unsulfonated, 3 parts; killed 98.2 percent of the larvae and pupae when brushed on the tree trunks, and 92 percent when applied with the atomizer.

Apple Fruitfly Investigations. (O.E. Hammer)

Seasonal Activities and General Importance During 1940

Fourteen emergence traps placed on artificially infested soil areas and examined daily during adult emergence yielded a total of 3926 flies. The first fly of the 1940 total emerged on June 20. The peak of emergence occurred on July 21 when 400 flies were captured. Successive activities were a few days later in 1940 than is usual, with flies being abundant in plantings relatively late in the season. This may account in part for the rather severe damage done by this insect in some Hudson Valley orchards where spraying with arsenicals was discontinued by July 1, and in plantings with enviromental conditions especially favorable to the apple fruitfly.

Insecticide Studies

Apple fruitfly control investigations conducted in Eastern New York and elsewhere have definitely established the fact that several arsenical insecticides are highly effective against this pest. Timeliness of application has also been established as an important factor for good control. All of the arsenicals generally used by Eastern New York apple growers, namely lead arsenate, calcium arsenate, and basic zinc arsenate, appear to be about equally effective against the adult flies. Unfortunately the latter two materials are less effective than arsenate of lead against the codling moth which also must be controlled during the period of apple fruitfly activity. Only one of the

so-called arsenical substitutes, namely phenothiazine, has shown any considerable promise of being effective against the apple fruitfly. The limitations to the use of phenothiazine in apple orchards in the northeastern part of the United States are well known to most investigators.

An effort is being made to formulate an insecticide schedule that will insure good control of the codling moth and apple fruitfly by employing a so-called split schedule. Such a schedule was tested in two plantings during the past season, one of the plantings having little codling moth and a light to moderate apple fruitfly infestation. The other planting had considerable codling moth and practically no fruitfly. It seemed desirable to use two plantings for this test since the habits of both insects differ enough to preclude the possibility of securing reliable data in any other manner. The control schedule employed and the results obtained in this test are presented in table 1.

In addition to the tests as summarized in table 1, a test was conducted to determine what place, if any, basic copper arsenate may occupy in the apple spray schedule in the Hudson River Valley. This material was used in three summer applications during 1939 and appeared to be as effective against the apple fruitfly as the other three arsenicals already mentioned in this report. During the 1939 season of high temperatures and light rainfall no appreciable injury resulted to Cortland apple foliage and fruit. In 1940 basic copper arsenate was used as the sole stomach poison in six post-bloom spray applications. Unlike the experience of 1939, the basic copper arsenate as used in 1940 caused severe injury to both fruit and foliage on all varieties in the planting. A high percentage of the fruit was severely russeted and this russeting began with the first post-bloom spray and increased in severity after each application. Foliage injury first became noticeable during the last ten days in August at which time the leaves began to turn yellow. Within a few days after yellowing the leaves began to fall and by mid-September many of the trees were completely defoliated. Data secured from the 1940 field testing of basic copper arsenate are presented in table 2.

Table 1. Results of Split Schedule to Control Codling Moth and Apple Fruitfly.

Insecticides and Amounts Used per 100 Gallons of Spray	Approx. Spray Dates	Apple Fruitfly Data: Variety	Apple Fruitfly Data: Percent Uninfested 1940	Apple Fruitfly Data: Percent Uninfested 1939	Codling Moth Data: Variety	Codling Moth Data: Percent Wormy Special Schedule *	Codling Moth Data: Percent Wormy Standard Check**
Lead arsenate 3 lbs.	6/15/40	McIntosh	97.0	94.5	Cortland average of 8 trees	4.2	30.7
Lead arsenate 1.5 lb. Calcium arsenate 1.5 lb.	6/27/40	"	93.4	82.2			
Proc. nicotine-bent.*** .4 lbs. Summer oil 3 qts.	7/7/40	"	96.0	92.4			
Same as above	7/15/40	"	99.4	97.6			
Calcium arsenate 3 lbs.	7/17/40						

* This plot of 8 Cortland trees in addition to receiving the schedule listed in the table, also received two second brood codling moth sprays of proc. nicotine-bentonite and oil. See plot 12, block 2, table 3, Poughkeepsie codling moth report.
** Standard check refers to a schedule consisting of a first cover of lead arsenate and two subsequent covers of calcium arsenate applied on the following dates, June 14, June 27, and July 11. See plot 1, block 1, table 2, Poughkeepsie codling moth report.
***Proc. nicotine-bentonite used 4.75 percent nicotine according to manufacturer, summer oil 83 percent actual oil.

Table 2. Results From the Use of Basic Copper Arsenate for Apple Fruitfly Control.

Spray Applications	Dates Applied	Insecticide and Amount Used per 100 Gallons Spray	Variety	Apple Fruitfly Control percent 1940	Apple Fruitfly Control percent 1939	Apples Russeted percent 1940
Calyx	May 13	Basic copper ars. 3 lbs. Hydrated-lime 3 lbs.	Wealthy*	97.9	----	10.8
Curculio	May 24		Wealthy	95.8	----	42.3
1st. cover	June 13		Delicious*	99.9	----	45.7
2nd. cover	June 28		Delicious	100.0	----	80.8
3rd. cover	July 10		McIntosh	99.4	78.4	98.4
4th. cover	July 22		Fameuse	89.9	10.9	99.4

* The calyx and curculio applications were omitted from these two trees, hence the greatly reduced amount of russeting of the fruit as compared with the sprayed trees of the same varieties.

GENEVA, NEW YORK

D. L. Collins, In General Charge
William Machado, In Immediate Charge

Light and Bait Trap Studies

During the season of 1940, the field experiments on responses of the codling moth were continued on a plan similar to that of previous years, but with one important change. The treatments of the two lighted areas, plat A (lights only) and plat B (lights and bait) were interchanged to provide a more critical test. In 1939 these two areas showed no significant difference in codling moth injury while area C (baited only) located between areas A and B had 20 percent higher injury.

The plats, treatments and numbers of trees are listed in Table 1.

Table 1. Plat treatment

Plat A - Bait traps and 2 cover sprays	24 trees
Plat B - Bait and light traps and 2 cover sprays	25 "
Plat C - Light traps and 2 cover sprays	25 "
Plat D - Random trees from all parts of the orchard treated as in Plat A	25 "
Plat E - Remaining trees in orchard treated as in Plats A and D	59 "

Only the trees in plats A, B, C and D were examined for codling moth injury at harvest time.

The entire orchard was sprayed by the grower from the delayed dormant spray through two cover sprays of lead arsenate. No other sprays were applied during the remainder of the season. Though applied at approximately the recommended intervals so much time was consumed for some applications or the spray so poorly applied because of inadequate equipment that its evenness of coverage and effectiveness were questionable.

The light trap used was of the electrocuting type (Folmer Insekiller, Models K and R) equipped with a 100 watt, type A, Mazda lamp and was hung as near as possible to the top and center of the tree.

All light traps were controlled by a photoelectric cell and a thermostat and were in operation from shortly after sunset to a corresponding light intensity at sunrise except during periods when the temperature was below 58°F.

The bait trap used was the same type as that used in 1939, consisting of a pair of glass quart jars filled with baits of different ages. The solution consisted of 10 percent dark brown sugar containing natural oil of sassafras at the rate of 0.5 cc. per quart emulsified with "Dreft." The bait in alternate halves of each trap was changed once weekly. A trap was maintained as near the top and center of the tree as possible.

At the beginning of the season all the trees were scraped of loose bark and banded. Untreated bands of heavy paper and burlap were used. Codling moth larvae were removed from the bands and counted weekly.

All drop apples were examined for codling moth injury and removed from the orchard. At the harvest two random bushels of fruit from each of the 99 trees in plats A, B, C and D were picked, examined for injury and counted. The total yield was also determined and estimates of the infestations made on the basis of total crop data.

The trap catches and band counts are recorded in tables 2 and 3.

Table 2. Trap Catches

Treatment	Average per trap	Percent females	Percent in bait traps	Percent in light traps	Percent of sum total
Bait traps - A	17.1	66.6			15.7
" " - B	2.1	81.1			2.0
Light traps - B	10.3	27.5			9.9
" " - C	19.9	34.0			19.1
Bait traps - D	15.2	65.1			14.6
" " - E	17.1	62.7			38.7
" " - A & B	9.4	68.3			17.8
Light traps - B & C	15.1	31.8			28.9
Bait & Light- B	6.2	36.7	17.0	83.0	11.9
All bait traps	13.9	64.6			71.1
All light traps	15.1	31.8			28.9
Sum total	16.5	55.1	71.1	28.9	

Note: Data for trap catches include figures from all traps in the orchard.

Table 3. Band Counts.

Treatment	Average number larvae per tree	Percent females
Plat A	37.7	56.4
" B	5.9	51.0
" C	21.4	54.3
" D	46.5	53.9
" E	41.3	51.5

Note: Figures are taken from all the trees in orchard.

The principal criteria used in evaluating the results were the band counts and fruit examinations. The data obtained are listed in table 4.

Table 4. Results of fruit examinations

Treatment	Apples per tree	Average number per 100 apples			
		Clean	Wormy	Worm entrances	Stings
A. Bait traps	2,348	81.7	10.9	14.3	10.6
B. Bait and light traps	1,227	93.2	3.9	5.1	3.7
C. Light traps	1,078	82.4	13.1	16.9	6.1
D. Bait traps	1,527	72.4	20.7	27.3	11.1

There was a generally lower population in 1940 than there was in 1939. The reduction in injury in plat C which had been changed from bait to lights was much greater than that in plat D which was equipped with bait both years. In Plat C there was a decrease in population considerably greater than the general trend but in plat A, which had been changed from lights to bait, there was a slight increase in population over 1939, contrary to the trend. The results of this reversal of treatments confirm the conclusion reached in single year experiments, that the light traps effected a conspicuous reduction in codling moth injury and population.

GENEVA, NEW YORK

S. C. Hendall and P. J. Chapman

BIOLOGICAL-MECHANICAL CONTROL

Two orchards were maintained in Orleans County in 1940 under this project, one receiving a regular codling moth spray program, and the other (biological-mechanical control orchard), located approximately one-third of a mile west of the sprayed orchard received only the sulfur sprays for apple scab. The crop in both orchards was 25-50 percent smaller in 1940 than in 1939, resulting in an increase in wormy fruit of 30 percent. Eighty percent of the entire crop in the biological-mechanical control orchard was injured by codling moth. However, the total population of worms in the orchard (estimated from inspections of dropped and picked fruit) was ten thousand less than that in 1939, a reduction of one hundred and forty worms per tree. All trees in this orchard were banded with untreated bands, and the dropped fruit was collected and removed from the orchard weekly. Four thousand worms were removed from the bands during the season, and twenty-one thousand worms were estimated to have been removed with the drops.

Parasitism by Ascogaster carpocapsae averaged 9.6 percent, double that of 1939. Predators found in the bands were more prevalent in 1940, the two most often found being Tenebroides dubia and T. corticalis. The average parasitism of codling moth eggs in the biological-mechanical control orchard by Trichogramma was 29 percent. This was considerably higher than in 1939, when the parasitism averaged only 3.8 percent. No liberations of Trichogramma have been made but almost one thousand individuals of Ascogaster were liberated during the past season.

In addition to the study of egg and larval parasites, corrugated strips of cardboard containing larval cocoons were placed in different localities throughout the biological-mechanical control orchard. After a week's exposure, the strips were placed in the field insectary. Insects reared from these strips were: Ephialtes inflatus Townes, Dibrachys cavus Walk., Ascogaster quadridentata Wesm., and Perilampus capitatus Smulyan. A Carbid, Harpalus pennsylvanicus DeGeer was found to be numerous in the biological-mechanical control orchard and predaceous on larvae in cocoons on the ground.

The sprayed orchard was divided into four different plots. One plot was sprayed with Cryolite, one with Black Leaf 155 concentrate, one with lead arsenate, and the other reserved as a check plot. The lead arsenate plot averaged 10 worms per tree; the nicotine plot 89 worms per tree; the Cryolite plot, 341 worms per tree; and the checks averaged 998 worms per tree. Egg and larval parasitism was very low in this orchard.

YAKIMA, WASHINGTON

E. J. Newcomer, In Charge

Seasonal Conditions

For the third season in succession there was a mild winter, the minimum being 15° F. in January, 1940. Very little winter mortality of the codling moth occurred. The season started out four or five days earlier than 1939, and was about 10 days earlier than normal. Temperatures during the latter half of May and June were above those of 1939, but in July and August the weather was somewhat cooler than in 1939 and there were fewer days of extreme heat. The first 10 days of September were abnormally warm. Although the seasonal rainfall was below normal, it was more than twice that of 1939. The total for May to September, inclusive, was 1.61 inches, most of which came in July and September.

Since the location of baits in 1940 was different from that of 1939, no direct comparison can be made. However, in one orchard in 1940, 38,000 moths were caught in 5 baits. This compares with 44,000 caught in a different part of the same orchard in 1939. In another orchard, where the infestation was lighter, 16,000 moths were caught in 5 baits.

Emergence of spring-brood moths started shortly after the middle of April, reached a peak just before the middle of May, and continued until late in June. The peak of egg deposition occurred late in May. First-brood moths appeared at the end of June, with a peak emergence early in July, although the greatest catch in baits did not occur until August. Moth activity continued until after the middle of September, resulting in a long season with heavy infestation.

Orchard Spraying Experiments

The spraying experiments were made in three orchards in 1940, using three-tree plats replicated four times in each orchard. There were thus 12 trees given each treatment in each orchard, from each of which random samples of 250 apples were taken at harvest, including both picked and dropped fruit. The orchards used were: (A) Delicious, about 18 to 20 years old, having a fairly heavy crop averaging 17 boxes to the tree, and a light infestation; (B) Rome, about 20 years old, having a light crop averaging 13 boxes to the tree, and a heavy infestation; and (C) Winesap, about 30 years old, having a heavy crop averaging 20 boxes to the tree, and a fairly heavy infestation. In orchard C, there were also three rows of Jonathans, same age and same size crop, with a heavy infestation, which were used for some of the tests.

Six cover sprays were applied in orchard A and seven in the other two, as follows: Calyx, Apr. 26 - May 3; First Brood, 1st cover, May 13-18; 2d cover, May 23 - 29, 3d cover, June 3 -11; 4th cover, June 13 - 22; Second Brood, 5th cover, July 8 - 15; 6th cover, July 23 - Aug. 3; 7th cover, Aug. 13 - 20.

Table 1.--Results of examination of orchard-sprayed apples for the control of the codling moth. Yakima, Washington 1940

Plat	Treatment (Quantities are for 100 gals.)	Orchard	% wormy[1]	% stung[1]	% free from worms & stings[1]	Residue at harvest mmg/sq.cm[2]
8	Phenothiazine, micronized; 2 lbs. stove oil, 1 qt; White King soap. 1 1/2 lbs.	A	3.9	1.6	94.9	10.8
		B	4.8	2.5	93.3	9.3
		C	1.3	1.4	97.5	22.1
		Av.	3.3	1.8	95.2	
1	Lead arsenate, 3 lbs; Pine tar soap, 1/4 lb; mineral oil, 3 qts. in place of soap in 3 cover sprays	A	5.9	22.1	74.0	20.4
		B	36.8	62.5	29.2	19.1
		C	12.4	45.5	50.6	18.5
		Av.	18.4	43.4	51.3	
10	Standard tank-mix nic.-bent. as in 3, 1st brood; lead ars. as in 1, 2d brood.	A	9.7	15.9	77.7	11.2
		B	36.4	52.0	36.2	11.4
		C	17.5	44.2	48.6	16.7
		Av.	21.2	37.4	54.2	
3	Standard tank-mix nic.-bent. Nic. sulfate, 1 pt. bent., 5 lbs; soybean oil, 1 qt.	A	11.4	9.3	80.8	1.3
		B	48.0	33.4	42.7	1.8
		C	25.6	33.2	52.0	2.6
		Av.	28.3	25.3	58.5	
5	Stand. tank-mix nic.-bent. with 1/2 oz. Dreft added. Nic.- sulfate & mineral oil in 2, 3 & last 2 cover sprays	A	17.3	14.0	72.1	1.2
		B	49.5	39.5	34.7	2.1
		C	29.2	34.4	48.8	1.8
		Av.	32.0	29.3	51.9	
4	Standard tank-mix nic.-bent. with 1/2 oz. Dreft added.	A	13.4	9.6	79.5	1.7
		B	52.7	38.4	33.4	2.6
		C	34.1	34.5	46.3	2.4
		Av.	33.4	27.5	53.1	
6	Phenothiazine, standard 2 lbs; stove oil, 1 qt; White King soap, 1 1/2 lbs.	A	56.3	20.2	37.5	5.6
		B	65.8	26.1	27.2	8.8
		C	34.6	18.5	55.6	18.1
		Av.	52.2	21.6	40.1	
7	Phenothiazine, standard, 2 lbs; beet molasses, 2 & 3 gal.	A	40.7	17.0	51.2	8.9
		B	85.8	39.8	9.0	13.2
		C	46.4	26.2	44.6	25.9
		Av.	57.6	27.7	34.9	
9	Xanthone, 2 lbs; sodium oleate, 1 lb; zinc sulfate 6 oz.	B	20.5	15.6	71.1	
		C	34.6	21.6	52.8	
		Av.	27.6	18.6	62.0	
2	Same as 1; 2d, 3d & 4th cover sprays delayed about 10 days	B	30.7	61.9	29.8	18.7
		C	48.7	49.7	29.5	14.4
		Av.	39.7	55.8	29.7	
1	Lead ars., 3 lbs; Pine tar soap 1/4 lb. Mineral oil, 3 qts in place of soap in 3 covers	B	36.8	62.8	29.2	19.1
		C	51.4	51.0	29.0	12.5
		Av.	44.1	56.9	29.1	

1/ Percent wormy not weighted; percent stung and percent free from worms and stings weighted according to size of crop on each tree.

2/ Analyses made by C. C. Cassil, Insecticide Division, Bureau of Entomology and Plant Quarantine. Figures are for As_2O_3 in plats 1, 2 and 10; for nicotine in plats 3, 4 and 5; and for phenothiazine in plats 6, 7 and 8.

The treatments tested, the results of the harvest counts, and the spray residue at harvest, are given in Table 1. The percentages stung and free of worms and stings are weighted within orchards, but the general averages of the three orchards are not weighted. The percentages of wormy fruit are not weighted at all in order that they may be used in connection with the following differences in percentage required for significance at odds of 99:1, as ascertained by analysis of variance:

Orchard A	7.7
" B	7.1
" C(Winesap)	9.5
" C(Jonathan)	14.4

Thus, the micronized phenothiazine (8) was significantly better than lead arsenate (1), and the contrast between it and the standard phenothiazine (6 and 7) is very striking. Nicotine-bentonite used for the first brood and followed by lead arsenate (10) was not significantly poorer than lead arsenate used throughout the season (1). The various nicotine-bentonite treatments (3, 4 and 5) were significantly poorer as regards wormy fruit, with the exception of 3 and 4 in orchard A. The standard phenothiazine (6 and 7) was very poor. Xanthone was significantly better than lead arsenate in both orchards, and the delayed application of lead arsenate (2) did not result in any significant difference from the regular applications.

Weekly examinations of 500 tagged apples in each of several of the treatments were made from July 18 to Sept. 5, and the following numbers of worms and stings occurred on these apples during this period:

Plat	Treatment	No. worms	No. stings
1. Winesap	Lead arsenate	27	171
3. Winesap	Nicotine-bentonite	60	79
8. Winesap	Phenothiazine (micro.)	2	2
1. Jonathan	Lead arsenate	269	183
9. Jonathan	Xanthone	71	40

The nicotine (3) caused much greater increase in worms than the lead arsenate (1), while the phenothiazine (8) allowed almost no increase. The increase on the fruit sprayed with xanthone (9) was much less than on that sprayed with lead arsenate.

Injury: In plat 7 (standard phenothiazine used with beet molasses), black pimples appeared on the fruit, apparently caused by the molasses, as they did not appear in plat 6. In plat 9 (xanthone), slight foliage injury occurred early in the season. The Jonathan apples became noticeably russetted, especially at the calyx ends, but this russetting did not occur on Romes.

Size of fruit: The average number of apples per box occurring in the various plats is given below:

Plat	Treatment	Size (av. No. apples per box)		
		Delicious	Rome	Winesap
1.	Lead arsenate	82	70	121
3.	Nicotine-bentonite (standard tank mix)	85	70	135
4.	Do., Dreft added	77	70	135
5.	Do., alt. with nic-oil	80	78	136
6.	Phenothiazine (standard) stove oil and soap.	76	68	141
7.	Phenothiazine (standard) molasses	78	77	141
8.	Phenothiazine (micronized) stove oil and soap	81	78	148
10.	Nicotine-bentonite, 1st brood; lead arsenate, 2d brood.	79	76	132
av.	all plats	80	73	136
			Rome	Jonathan
1.	Lead arsenate		70	122
2.	Do., delayed		76	127
9.	Xanthone		71	139

There was no effect from any of the sprays on the size of Delicious or Rome apples. It might appear that the nicotine treatments had influenced the size of Winesaps. This was not evident in previous years, however. It appears also that the phenothiazine resulted in smaller Winesaps. There is evidence, too, that xanthone reduced the size of Jonathans, and this effect may be related to the russeting of this variety.

Color of fruit: There was a very marked reduction in the color of fruit by the phenothiazine, the average percentage of extra fancy color on the three varieties being only 46, as compared with 71% in the fruit sprayed with lead arsenate. No effect on color resulted from nicotine or xanthone.

Biological Studies

Moth Emergence Records: The first emergence was observed April 18 and the peak of the spring brood emergence occurred between May 7 and 14. About 40 percent of the spring brood emergence was observed after the above peak. Most of the late moths emerged from cool shaded places about the tree and from the ground. The maximum number of emergences from the ground was observed during the last two weeks of June -- over a month after the peak of emergence from the trees. First brood moths began to emerge about the first of July and reached a peak about July 15. There was a gradual decrease from the middle of July until the end of the season.

Bait records (molasses baits): The first moths were caught April 19 and the peak of the spring brood catch occurred May 17 - 23. The peak was reached about a week after the peak of emergence. First brood moths appeared in the baits at the beginning of July and increased to a peak during the first week of August. The catch was high during August and decreased sharply during the first half of September.

Egg deposition and larval entrances: Eggs were first observed on May 13 and reached a peak between May 17 and May 23, which was during the peak of moth catch in baits. Eggs were deposited continuously during June. There were two peaks of deposition by first brood moths -- one about the middle of July and the other about the middle of August. These peaks were both more or less indicated by bait catches. First brood larvae entered the fruit in maximum numbers about 10 days after the peak of egg deposition. During July and August about a week was required for the eggs to hatch.

Rotary net records: A rotary net was constructed similar to those in use for catching the beet leafhopper, pea weevil, etc., in an attempt to find a method to determine the moth population in an orchard without the use of attractant lights or baits. The apparatus has two nets, 10 and 15 feet high, which rotate on a horizontal plane. The arms holding the nets are 7 feet long, thus the diameter of the paths of the nets is 14 feet. The screen nets, 18 inches in diameter at the large end, are operated by a 1 h.p. electric motor at a speed of about 20 m.p.h. The apparatus was placed between two trees so that the lower net nearly touched the branches of two trees, while the upper net was opposite the tops and about 8 feet away. Operation of the net was begun during the last of June, and continued until September.

During most of the season the number of moths caught in the lower net closely approximated the average number caught in baits, but after the middle of August the number caught by the net fell behind. The upper net caught only 10% as many moths as the lower one. The average daily catch in the lower net was 64.5 moths and the average daily catch per molasses bait,

in the same part of the orchard, was 77.3 moths. This appears to be a very promising method of determining seasonal moth population in an orchard.

Comparison of the Kirsten Light traps and molasses baits: Two Kirsten light traps, operated in a commercial orchard, were made available for comparison with molasses baits in the same orchard about 125 yards away. The Kirsten trap has a tube of infra red light arched over a small transformer box, and a tube of ultra violet light around the box horizontally. The light unit is placed in the top of a metal funnel. A jar containing some calcium cyanide is fastened to the bottom of the funnel to catch the moths. The traps were hung from poles which were between two rows of trees, at about the height of the tree tops.

The traps were in operation 30 nights during May and June. With only a few exceptions the catch per unit was higher in the molasses baits. The total catch in the light traps was 264 moths per unit, while the total catch in the molasses baits, during the nights the light traps operated, was 472 moths per unit. The owner discontinued the Kirsten traps June 18 because of the disappointingly small catch of moths. Had the traps been operated later, it is probable that they would have given a better account of themselves, as during the period of operation temperatures, after it was dark enough for the lights to be effective, were mostly too low for much flight. Later in the season, this would not have been the case.

Orchard Sanitation Experiments

Experiments with orchard sanitation (scraping and banding) were continued in the Gilbert orchard for the 6th season, and in the Sundquist orchard, formerly the Buchanan orchard, for the second season. A new set-up in the E. A. Bannister orchard was operated for the first time. In the Gilbert orchard (table 2) with two less spray applications (the 3rd and 5th covers) omitted in the sanitation plat, there was less control than in the check. Last year with one spray omitted in the sanitation plat, the crop was still cleaner than in the check, although there were a few more wormy apples. Last year Jonathans were 18.3 percent wormy in the sanitation plat and 17.5 percent in the check; 58.4 percent clean in the sanitation and 49.1 percent in the check. Winesaps were 3.4 percent wormy in the sanitation plat and 4.6 percent in the check; 70 percent clean in the sanitation plat and 65.7 percent in the check. In 1940, however, Jonathans were 22.5 percent wormy in the sanitation plat, and 13.6 percent in the check; 56.0 percent clean in the sanitation plat and 63.9 percent in the check. Winesaps were 8.6 percent and 3.6 percent wormy in sanitation and check plats respectively; 64.6 and 80.2 percent clean in sanitation and check plats respectively.

Table 2.--Results of Scraping and banding experiments, Yakima, Washington, 1940

Orchard	Variety	Percent of apples wormy		Percent of apples stung		Percent of apples clean	
		Sanitation plat	Check Plat	Sanitation plat	Check plat	Sanitation plat	Check plat
Gilbert	Jonathan	22.5	13.6	30.1	27.7	56.0	63.9
	Winesap	8.6	3.6	30.7	17.9	64.6	80.2
Sundquist	Jonathan	13.8	30.0	23.1	47.5	67.6	40.8
	Winesap	6.7	10.0	33.2	53.2	64.2	44.8
	Delicious	11.5	18.7	31.4	55.8	63.0	39.7
	Rome	11.2	16.8	28.5	55.0	66.7	42.3
Bannister	Winesap	7.4	9.0	37.9	41.2	58.3	55.4
	Delicious	10.7	13.8	41.3	45.2	54.3	49.4
	Rome	11.3	17.7	45.1	55.0	50.7	39.3

In the Gilbert orchard there was 7.8 percent more apples on the Jonathan check count trees than on the sanitation count trees, and 13.5 percent more Winesaps. This difference is probably not significant. In all comparisons in the other orchards the crop was invariably larger on the sanitation count trees than on checks.

The Sundquist set-up was somewhat cleaner than in 1939 in all varieties except Winesaps, which, because of a much lighter crop this year, showed a higher percentage of infestation. All four varieties in the sanitation plat, however, showed cleaner fruit than in the check plat.

The Bannister orchard set-up consisted of about 25 acres, isolated on three sides, and with a few acres of more or less scattered but cared-for trees on the fourth side. The sanitation plat was scraped after much moth emergence had taken place and therefore the full benefit of the scraping program was not obtained. Bands were applied in early June as in other orchards. All three varieties examined were freer of worms and stings in the sanitation plat than in the check, but the difference was probably not significant except in the Romes which showed a difference of 11.4 percent in control between the sanitation and check plats.

Summarizing six season's tests, every one of the 43 comparisons by varieties, shows a more or less definite increased control for the sanitation program, except the two in the Gilbert orchard in 1940, which, with two sprays omitted in the sanitation plat, showed considerably less control than the check.

Average worm capture in bands: Bands in the Gilbert orchard, the only one examined to date, show that Jonathans averaged 248.6 worms per tree and Winesaps, 127.9. This was an increase of 9.9 percent in the average number caught on Jonathans and 220.3 percent on Winesaps over the 1939 average.

Percent of exited larvae caught in bands: In tests to determine the percent of exited larvae caught in bands on trunks or trunks and limbs of scraped trees, out of a total of 9958 larvae that had left the fruit on 32 trees, 5417 larvae were captured in bands, or 54.5 percent. (Last year 44.4 percent and the year before 45.0 percent). The highest percentage caught was on Jonathans in the Sundquist orchard, 66.1 percent, and the lowest, on Winesaps in the Bannister orchard, 37.0 percent. Bands on Jonathans and Romes capture a larger proportion of the larvae leaving the fruit than they do on other varieties, partly due, as stated last year, to the thoroughness with which these varieties can be readily scraped, and also to the large proportion of naturally smooth bark surface where there are no hiding places for the larvae.

Comparison of bands on trunks and trunks and limbs: Analysis of the proportion of larvae caught in bands on trunks and trunks and limbs in the tests to determine the percentage of exits caught in bands, shows that the trunk bands alone, on alternate trees, caught 44.8 percent of the exits while trunk and limb bands on the same number of alternate trees caught 64.9 percent. In every case the combinations of trunk and limb bands caught more than trunk bands alone, but required 3 times as much additional banding material.

The least proportion of exits caught in trunk bands was 25.2 percent on Delicious, the highest, 53.8 percent, in Romes. The least proportion of exits caught in trunk and limb bands was 48.5 percent, in Winesaps; the highest, 73.9 percent, in Romes. In 1939, when bands were shifted weekly throughout the season, alternating between trunks, limbs, and trunks and limbs, the combination of trunk - limb bands averaged about 50 percent more larvae than trunk bands alone. This season, without shifting, the same combination caught about 45 percent more than trunk bands alone.

Location of hibernating larvae on trees scraped and banded in 1939

A. As to part of tree: Minute examination of every inch of surface of 22 trees scraped and banded in 1939, showed the location of hibernating larvae in the spring of 1940 as shown in table 3,A.

B. As to kind of location: These same data were reassembled as to kind of location (table 3,B).

Table 3.--Location of hibernating larvae as to part of tree, and as to nature of location. Survey of 22 trees scraped and banded the previous season. The data in both parts of the table are from the same trees.

A. Location of hibernating larvae as to part of tree			B. Location of hibernating larvae as to kind of location		
Location	Average No. of larvae	Percent of total	Location	Average No. of larvae	Percent of total
Trunk	3.8	21.2	Rough bark	4.8	26.9
Scaffold limbs	3.9	22.0	Pruning wounds	2.5	14.3
Branches	8.9	50.2	Crotches	4.9	27.4
Attached to trunk in soil	0.9	5.1	Knots	4.2	23.5
Miscellaneous*	0.27	1.5	Broken limbs	0.23	1.3
Average per tree	17.8		Attached to trunk in soil	0.91	5.1
			Miscellaneous*	0.27	1.5

* In addition to these, by sifting and examining trash and soil in 1/4 area under each tree, the following were found: 1 at one Winesap tree, 1 at a Jonathan, and 3 at a Rome, out of 22 trees.

Location of hibernating larvae on unscraped trees:

A. As to part of tree: Minute examination of every inch of surface of 14 trees that had never been scraped or banded, showed the location of hibernating larvae in the spring of 1940, as shown in Table 4,A.

B. As to kind of location: These same data were reassembled as to kind of location (table 4,B).

Table 4.--Location of hibernating larvae as to part of tree, and as to nature of location on 14 unscraped trees. The data in both parts of the table are from the same trees.

A. Location of hibernating larvae as to part of tree			B. Location of hibernating larvae as to kind of location		
Location	Average No. of larvae	Percent of total	Location	Average No. of larvae	Percent of total
Trunk	31.1	35.7	Rough bark	45.7	52.5
Scaffold limbs	36.6	42.0	Pruning wounds	1.7	2.0
Branches	9.93	11.4	Crotches	23.7	27.3
Attached to trunk in soil	8.1	9.3	Knots	6.1	7.0
Trash in soil	0.93*	1.1	Broken limbs	0.29	0.3
Miscellaneous	0.43	0.5	Attached to trunk in soil	8.1	9.3
Average per tree	87		Trash & soil	0.93	1.7
			Miscellaneous	0.43	0.5

* Calculated from examination of 1/4 area under trees. Actually 2 found at one tree and 2 at another for the whole 14 trees.

Comparison of location of hibernating larvae on unscraped trees and trees scraped and banded in 1939: Trees scraped and banded in 1939 showed an average of 17.8 larvae per tree in the spring of 1940, compared with 87 on unscraped trees. On scraped trees 50 percent of the hibernating larvae were on the branches where evidently there were more suitable hibernating quarters than elsewhere. Unscraped trees had only 11.4 percent on the branches but 77.7 percent on the trunks and scaffold limbs. No hibernating larvae to speak of were found in the trash and soil unattached to the tree at either scraped or unscraped trees. When the rough bark is removed by scraping a larger proportion of the larvae become established in pruning wounds and about knots than where the rougher bark is present for them to hide in.

Loss of beta-naphthol in chemically-treated bands: Beta-naphthol bands, consisting of two formulae of 4 chemical loads each, prepared by Dr. E. H. Siegler, and commercial bands prepared for 1939 but unopened, and 1940 commercial bands, were applied on orchard trees June 10 and removed September 4. Samples of each kind were saved at both dates for chemical analysis. Analysis by Mr. C. C. Cassil, of the Insecticide Division, showed an average loss of 65 percent for all bands. All bands containing aluminum stearate in addition to beta-naphthol lost about 80% while those containing none lost about 55%. Unopened year-old commercial bands lost 57 percent compared with 47 percent for 1940 bands. Evidently year-old unopened bands, (if stored in a cool place as these were) are satisfactory to use, although the loss of beta-naphthol may be somewhat greater than from new bands.

Codling moth larvae from 1938 transform to moths in 1940: In an orchard that was badly infested in 1938, and which had many fruitless trees in 1939, thousands of hibernating larvae from 1938 failed to pupate in the soil and transform to moths in 1939. In cages built about several tree trunks in this orchard in 1939, some 900 moths emerged from the 1938 or two year-old larvae in 1940, thus substantiating more meagre observations by others that codling moth larvae may survive two seasons before transforming to moths.

KEARNEYSVILLE, WEST VIRGINIA

Edwin Gould, In General Charge
G. H. Geissler, In Immediate Charge

These investigations were carried on jointly by the Bureau of Entomology and Plant Quarantine and the West Virginia Agricultural Experiment Station.

1. Seasonal Conditions and Codling Moth Abundance During the 1940 Season.

In the Shenandoah Cumberland fruit belt the active season of development of fruit and insects was abnormally late in beginning. Grimes and Jonathan varieties began the general peak of bloom on May 11. In 1939 the petal-fall spray was applied May 6 and in 1940 it was necessarily delayed until May 18. Bloom was heavy and good weather brought about an excellent set of fruit in the area.

The first codling moth appeared in the bait pails on May 14, seven days later than in 1939. It is of interest to note here that the development of moths and fruit both remained a week or more late throughout the season. Harvest operations were completed later than usual. Activity during the first brood was short and intense, covering a period of approximately 29 days as compared with 45 in 1939. Peak of first brood activity took place on May 30. Immediately following the peak of activity the number of moths recorded from the pails was reduced to an almost negligible figure. This low level was maintained until the beginning of the second brood. The opposite was true in 1939 when a heavy moth catch persisted three weeks or more after peak. The delayed emergence of moths brought about a concentrated period of activity and made control measures relatively easy where adequate and properly timed sprays were utilized. Growers who failed to follow recommended schedules suffered severe losses of fruit.

The second brood activity of moths began one week later than in 1939. From its beginning on August 1 emergence and activity continued heavy well into September. The peak of second brood was reached on August 20.

Throughout the season records were kept on hatching and entry of codling moth larvae by the daily examination of 200 fruits. The peak of hatch for first brood as indicated by this source, occurred on June 25, and on August 19 for the second brood. Hatching continued until at least October 1 and accounted for what appeared to be a greater than usual number of early instar larvae present in harvested fruit. A very substantial carry-over of larvae is anticipated for the 1941 season.

2. Field Experiments with Insecticides.

The spray tests for 1940 were designed originally to reduce the first brood to the point where second brood spraying could be entirely eliminated. Because of the short duration of the first brood, it was found impossible to apply more than three of the four sprays planned to

accomplish this result. Although control in the bulk of the tests was excellent at the end of first brood one second brood spray was applied mainly in order to protect the grower.

Fifteen treatments were included in the group. All treatments were applied in duplicate orchards using the single tree plot system, with 5 one-tree replicates in each orchard. One orchard (Stewart) is considered as heavily infested, while the second (Shryock) is lightly infested. First brood counts were made in both localities in addition to the usual drop and harvest counts. A study of the tables included shows the difficulty of attempting to evaluate the results in most of the treatments due to the fact that control was exceptionally easy to effect. Treatments 13, 14 and 15 designed as non-wash schedules show a rather high percent of injured fruits indicating that the infestation was of sufficient proportions to warrant experimental work.

Results of Field Experiments with Insecticides for Codling Moth Control, Stewart and Shryock Orchards, Kearneysville, W. Va., 1940.

Treat. No.	Materials (Amounts per 100 gals.) * **	Orchard	Total Apples	Percent sound apples		Total injury per 100 apples	
				1st brood	Total	Worms	Stings
1	1st cover: L.A., Flot. Sul., Lime (6 lbs.); 2nd, 3rd & 4th covers: L.A., Bordo.	Stewart	31650	84.2	83.5	2	22
		Shryock	24627	93.2	88.1	1	16
2.	Same	Stewart	29848	82.1	78.9	4	29
		Shryock	41294	90.5	87.0	2	18
3.	Same	Stewart	38538	83.1	82.8	3	23
		Shryock	32800	91.4	89.5	1	13
4.	1st cover: L.A., Lime (6 lbs.) 2nd, 3rd & 4th covers: Proc. Nic-Bent., Nic., Sum. Oil.	Stewart	35546	90.6	90.7	2	11
		Shryock	24889	95.5	94.5	1	6
5.	1st cover: L.A., Lime (6 lbs.) 2nd cover: L.A., Sum. Oil, Bordo. 3rd & 4th covers: L.A. Bordo.	Stewart	35461	89.7	84.6	3	21
		Shryock	31905	92.8	90.4	2	13
6.	1st cover: L.A., Lime (6 lbs.) 2nd & 3rd covers: L.A., Sum. Oil, Bordo. 4th cover: L.A., Bordo.	Stewart	34796	88.7	90.9	1	12
		Shryock	24596	94.9	92.5	1	10
7.	1st cover: L.A., Lime (6 lbs.) 2nd cover: L.A., Nic., Sum. Oil, Bordo.; 3rd cover: L.A., Sum. Oil, Bordo.; 4th cover: L.A., Bordo.	Stewart	23089	90.5	85.8	3	18
		Shryock	27672	93.1	90.9	1	12
8.	1st cover: L.A., Lime (6 lbs.) 2nd & 3rd covers: L.A., Br.Sugar, Bordo. 4th cover: L.A., Bordo.	Stewart	21546	83.3	84.0	3	23
		Shryock	30296	90.1	83.9	3	23

Results of Field Experiments with Insecticides for Codling Moth Control - Continued

Treat. No.	Materials (Amounts per 100 gals.) * **	Orchard	Total Apples	Percent Sound apples		Total injury per 100 apples	
				1st brood	Total	Worms	Stings
9.	1st cover: L.A., Lime (6 lbs.) 2nd & 3rd covers: L.A., Sum. Oil, Br. Sug., Bordo.; 4th cover: L.A., Bordo.	Stewart	29779	91.7	90.8	1	10
		Shryock	35232	92.7	91.3	1	11
10.	1st cover: L.A., Lime (6 lbs.) 2nd & 3rd covers: L.A., Bent., Br. Sug., Orvus., 4th: L.A., Bordo.	Stewart	31700	82.9	77.9	8	28
		Shryock	25370	92.8	86.1	2	18
11.	1st cover: L.A., Flot. Sul., Lime (3 lbs.) 2nd & 3rd & 4th covers: Xanthone, Sod. Ole., Zinc Sul.	Stewart	30669	85.6	77.0	24	17
		Shryock	25752	92.8	83.9	10	14
12.	1st cover: L.A., Flot. Sul., Lime (3 lbs.); 2nd cover: L.A., Lime. 3rd & 4th covers: Xanthone, Sod. Ole., Zinc Sul.	Stewart	30895	76.3	75.9	16	26
		Shryock	27163	90.6	85.0	4	18
13.	1st cover: L.A., Flot. Sul., Lime (3 lbs.) 2nd cover: L.A., Bordo. 3rd cover: Cal. A., Bordo.	Stewart	19483	76.0	64.1	42	44
		Shryock	26653	88.8	78.8	6	33
14.	1st & 2nd covers: same. 3rd cover: Nic., Sum. Oil.	Stewart	26167	79.5	71.8	29	26
		Shryock	23688	89.7	81.9	6	25
15.	1st & 2nd covers: same. 3rd cover: Nic., Lime (3 lbs.)	Stewart	22854	77.5	67.7	38	30
		Shryock	29049	89.1	76.8	12	31

* - All treatments except Nos. 2 and 3 received a petal-fall spray of lead arsenate, 3 lbs.; Lime-sulphur 2 gallons; Lime 6 lbs. Lead arsenate was omitted from this spray on Nos. 2 and 3 in order to test the value of this procedure. Since the first cover spray occurred only 8 days after calyx these two treatments were, according to their original plan, changed to become the same as the standard (No. 1) treatment with the exception of the petal-fall spray.

** - Abbreviations used in the foregoing table include the following:

Bordo = 2-4-100 Bordeaux
Flot. Sul. = Flotation Sulfur, 5 lbs.
L.A. = Lead Arsenate, 3 lbs.
Lime = Amounts indicated in table.
Nic. = Nicotine Sulfate (40% nicotine) 1 pint.
Sum. Oil = White or summer oil emulsion, 1 gallon.
Proc. Nic. Bent. = Factory processed Nicotine-Bentonite, 4 lbs.
Xanthone = Commercial Xanthone, 2 lbs.
Sod. Ole = Sodium Oleate, 1 lb.
Zinc. Sul. = Zinc Sulphate, 4.5 oz.
Br. Sug. = Brown Sugar, 12 lbs.
Orvus = Orvus, 1/2 oz.
Cal. A. = Calcium Arsenate, 4 lbs.
Bent. = Bentonite, 5 lbs.

The results presented in the foregoing table show definitely the ease with which codling moth was controlled by means of adequate and timely sprays. No. 1, the standard lead-arsenate schedule, remains the most effective and economical of any of the treatments under consideration. It produced 83.5 percent clean fruits in the heavily infested Stewart orchard a difference of slightly over 1 percent less than was present during first brood.

No. 4 the processed nicotine bentonite plot with summer oil and 40% nicotine sulphate added gave better control than any of the other materials. Severe defoliation from this combination resulted, however, and fruit finish was badly impaired. Nos. 5, 6 and 7 containing summer oil and nicotine sulphate added to the standard schedule all gave satisfactory results. No. 6 was particularly efficient, producing 90.9 percent clean fruits in the Stewart orchard with summer oil added to the second and third cover sprays. No. 7 with the same schedule, but having nicotine sulphate added to the second cover, gave slightly poorer results producing 85.8 percent clean fruits in the same orchard.

No. 8, 9 and 10 contained brown sugar in combination with various lead arsenate mixtures. All but No. 10 containing 5 pounds of bentonite in place of the 2-4-100 Bordeaux gave results comparable to the standard (No. 1) schedule. The brown sugar used at 12 pounds per 100 gallons appeared to add nothing to the control value of these combinations. Nos. 8 and 9 were severely injured in the first sprays which included sugar. No. 10 produced injury when Bordeaux was applied in the 4th cover.

The Xanthone treatments showed little promise as shown in treatments 11 and 12. No. 12 beginning with two covers of lead arsenate followed by two of Xanthone, as recommended by the manufacturer, produced fewer worms, but as many total injuries as No. 11. No. 11 began the Xanthone earlier with the second cover spray and produced a total of 14.4 percent of its fruits wormy. The second brood, ineffective on treatments containing lead arsenate in the 4th cover, was very severe on these two treatments. Both of these treatments showed badly injured foliage although finish and color of fruit were satisfactory.

Plots 13, 14 and 15 were applied as non-wash schedules. They illustrate the futility of growers attempting to raise quality fruit by means of such schedules where the codling moth is a considerable factor. They indicate also that both orchards had an infestation of sufficient proportions to warrant experimental spraying. They further emphasize the ease with which control was obtained in this area when proper schedules were in use.

3. Biological-Mechanical Control.

This project was begun in 1935 and was planned in order to observe and study the codling moth under a virtually non-spray program. The five years planned as necessary to accumulate sufficient data for this purpose is at an end. Though the project in its entirely is as yet not completely summarized, many of the salient points can be presented. They are found in the tables below.

Table 1

Year	Total Crop in Bushels	% Crop Dropped	Percent Fruits Injured		
			Drops	Harvest	Total
1935	-	50.3	91.2	66.4	77.9
1936	6593	60.9	71.3	33.7	55.4
1937	3421	44.5	88.7	58.3	71.8
1938	5106	66.3	75.7	36.4	62.5
1939	3352	50.4	76.6	46.6	61.7
1940	3507	35.2	87.5	63.6	72.0

Table 2

Year	Ave. Yield per Count Tree	% Wormy	% S.& W.	% Stung	% Parasitized	% Predatored
1935	998	48.0	22.0	7.9	--	--
1936	5070	47.7	4.7	3.0	3.5	2.3
1937	1923	37.9	22.2	11.7	6.5	10.5
1938	3408	45.0	13.7	3.8	6.6	12.6
1939	1357	34.7	19.2	7.8	5.4	13.3
1940	1945	42.9	24.6	4.5	4.0	4.2

Although the above summaries are largely self-explanatory some discussion is necessary to clarify most of the figures.

In table 1 fewer fruits are shown to have dropped in 1940 than previously. Also recorded is the second highest percent of injured picked fruits. It is pointed out that the percent total crop which drops directly affects the intensity of worm injured picked fruits. This correlation can be followed for each of the years presented. The light 1940 drop was due to an early harvest in the Biological-Mechanical Control orchard. It has been found that late harvest produces heavy drop and vice versa.

The total injured fruits was 72.0 percent in 1940 - the highest recorded since the orchard has been under treatment. This was doubtless due in part to moderately favorable weather conditions for development during both broods. Another factor possibly contributing to the heavy infestation was the sudden drop in predatored larvae (table 2). The 4.2 percent represents a considerable drop over that recorded for 1939. These counts are made by the weekly examination of untreated bands and show only the relationship of predatorism between seasons. Population behavior studies in 1939 showed that approximately 40 percent of a given population was destroyed by predators. It is easy to visualize what a drop from 13.3 percent to 4.2 percent will do in the way of increasing the codling moth population.

The percentage of larval parasitism is of little significance. Band records as recorded in table 2 are almost identical with rearing records. Apparently a fair proportion of parasitised larvae reach the bands. Since the percent of parasitism is so low the slight changes recorded from year to year are of little consequence.

A summary of 1st brood and drop harvest counts is given below.

Table 3 - Three Year Summary of Type and Degree of Injury Caused by 1st and 2nd Brood Larvae

	Degree and Type of Inj. 1st & 2nd Brood						: Degree of Infestation of		
	1st Brood			Total			: 1st and 2nd Brood		
Date	Wormy Fruits	Wormy & Stung	Stung Fruits	: Wormy Fruits	Wormy & Stung	Stung Fruits:	1st Brood Injury	2nd Brood Injury	Tot. Inj.
1938	14.3	1.3	2.3	45.0	13.7	3.8	28.7	71.3	62.7
1939	18.6	8.5	10.9	34.7	19.2	7.8	61.6	38.4	61.7
1940	23.0	7.0	6.5	42.9	24.6	4.5	50.6	49.4	72.0

Comparing the degree of first and second brood infestation, the 1938 records show only 28.7 percent of the total seasonal injury caused by the first brood compared with 61.6 percent in 1939 and 50.6 percent in 1940. Important is the fact that the total infestations in 1938 and 1939 were about the same, whereas that in 1940 was approximately 10.0 percent greater. This indicates that the degree of first brood infestation is not a positive criterion of the total infestation. In 1938, 28.7 percent of the total injured fruits were attacked by first brood as compared with 61.6 percent in 1939 and 50.6 percent in 1940. Weather conditions during first brood in 1938 were unfavorable to development, but during second brood they presented almost optimum conditions. Just the reverse was true in 1939 resulting in both years having almost the same final results. In 1940. however, weather was favorable during both broods resulting in a considerably heavier infestation than the previous two years.

VINCENNES, INDIANA

L. F. Steiner, In Charge

Seasonal Conditions

The carryover of larvae from 1939 was larger than normal despite subnormal winter temperatures.

The late 1939 drought continued through 1940 (though temporarily broken in April) so that by the end of October the rainfall for the preceding 16 months was 46 percent below normal. For the period July 1 to October 31 the deficiency amounted to 56 percent of normal. The premature dropping of fruit was not as severe as in 1939 but more wilting of foliage and stunting of fruit was evident. The 1939 drought, unfavorable weather during the blooming period, freezes in April, and a scarcity of bees combined to produce a light set of fruit. Some varieties like Grimes, Rome Beauty, York and Starking generally bore normal crops, others like Winesap, Jonathan, Golden Delicious and Turley set very little fruit although there were frequent exceptions.

Mean daily maximum temperatures were subnormal through most of the season but minimum temperatures were above normal so that in June, July, and August extreme temperatures that would slow up development were rare. In July codling moth eggs were observed hatching in the orchard 5 days after deposition.

Codling moth pupation began not later than April 3, moths began emerging about May 7 and bait traps showed two main peaks of spring-brood activity about May 21 to 23 and June 3 to 5. The population remained at a high level (measured by periodic funigation of 10 trees) until after the middle of June and was still within 30 percent of its peak after 99 percent of the moths in cages had emerged. Oviposition was heavier toward the end of June than any time prior to then. After the middle of July the attack was constant and severe until October with adults most abundant from July 18 to August 1 and from August 29 to September 5. The heaviest larval attack of the season occurred between September 5 and 15th.

Most growers in the middle west had heavier infestations in 1940 than in 1939 with the result that the present hibernating brood, on varieties which bore crops, is one of the largest in recent years.

Control by Insecticides

Insecticide tests were of 4 types, laboratory, laboratory-field, single tree replicated plot, and large-scale control tests. All were supplemented wherever possible with chemical analyses of spray deposits by the Division of Insecticide Investigations.

Leads developed in the winter laboratory tests in which some 60,000 newly hatched larvae were employed were followed up in the laboratory-field experiments.

Laboratory-Field Experiments

More than 50 formulas and variations in schedules were tested by this method, about a third of them being followed throughout the season, and the others for shorter periods.

Stratified samples of fruit taken periodically (usually before and after all spray applications) from the field plots, are exposed to a known number of newly hatched larvae in the laboratory. The technique was tested statistically and the use of 80 apple samples (from 2 or more trees) and 640 larvae per test was found to give very reliable results. Efficiency is calculated by comparing entrances (stings disregarded) in the treated fruit with those made in unsprayed check samples. The method has been described in previous reports and is outlined in detail in multigraphed circular E-488 (September 1939).

The principal series of tests was conducted on rather large 18 year old Grimes trees. Plots were arranged for convenience in spraying since no harvest counts were intended. Sprays were applied from a portable outfit supporting a 9 ft. tower, and from the ground, each cover being a complete inside-outside application. All parts of the trees were sprayed to the point where run-off began.

The outfit was operated at 550 pounds pressure and disk size adjusted to hold the total output between 12 and 15 gallons per minute. Usually a 3-nozzle broom was used on the ground and a "Windmaster" gun in the tower.

A total of 290,000 newly hatched larvae were used in the 1940 laboratory-field tests.

Some of the more important results have been averaged and summarized in Table 1. This method of presentation fails to show the effects of individual spray applications, heavy rains, prolonged interspray periods, etc. or the degree of protection present at critical periods but it makes possible a simple comparision of the treatments for the season as a whole.

A calyx and calyx top-off of 3 pounds lead arsenate, 3 pounds lime and 10-12 pounds flotation sulfur paste per 100 gallons was applied on May 6 and 9 respectively.

Cover sprays were applied as follows:

1st,	May 21	5th,	July 9
2nd,	" 31 (Nicotine Plots)	6th,	" 24
	June 1 (Others)		
3rd,	" 10	7th,	Aug. 7
4th,	" 19		

Table 1. Average percent larvicidal efficiency and spray deposits before and after cover sprays and at harvest. Vincennes, Indiana. 1940
(Nicotine, phenothiazine and As_2O_3 deposits in parentheses as mmgs. per sq. cm. from data of Division of Insecticide Investigations)

Abbreviations used: LA. (lead arsenate), Bdx. (3/4 - 1 1/2 - 100 bordeaux mixture), Bent. (Wyoming pellet type bentonite), Nic. (Nicotine sulfate 40%) MO. (mineral oil emulsible type - 98% oil), Soap (Sodium oleate), F.P.N.B. (factory-processed concentrate nicotine bentonite, 14% nicotine). S. oil (soybean oil, crude domestic raw), STM (standard tank-mix 1 pt. Nic., 5 lbs. bent., 1 qt. S. oil first 4 covers. 0.67 pt. Nic. 3.3 lbs. bent., 1 qt. S. oil in last 3 covers).

Plot.	Materials per 100 gals.	2nd to 4th cover sprays		5th to 7th cover sprays		Harvest 9/10
		Before	After	Before	After	
	Lead arsenate, Xanthone, Phenothiazine Treatments					
1.	LA. 4 lbs. in first 3 covers, 3 lbs. in last 4. Bdx. in all, 2 qts. MO. in 2nd and 3rd.	41 (10.4)	56 (18.5)	60 (15.8)	70 (20.1)	72 (15.3)
2.	Xanthone 2 lbs., Zinc sulfate 4 1/2 ozs., Soap 1 lb.	12	32	9	51	0
3.	Same as Plot 2 + Bdx. (4-6-100 bdx. in 4th)	13	41	(discontinued)		
10.	Phenothiazine 4 lbs. (No supplements. Wet by agitation)	36 (8.1)	75 (26.0)	49 (8.7)	85 (27.6)	50 (11.3)
11.	Micronized phenothiazine 4 lbs. in first 3 covers, 3 lbs. in last 4. (Wet as Plot 10)	68 (13.7)	95 (38.9)	79 (12.9)	94 (30.2)	73 (14.7)
	Nicotine Bentonite Treatments					
4.	F.P.N.B. 3 lbs., bent. 2 lbs. (1 lb. after 4th cover).	43 (3.2)	61 (6.0)	69 (2.7)	84 (5.8)	73 (2.7)
4B.	Same as 4 + S. Oil, 1 pt. after 4th cover.	"	"	72 (2.9)	87 (5.5)	77 (3.0)
5.	STM	67 (4.6)	82 (8.6)	86 (3.7)	93 (6.5)	81 (3.3)

TABLE 1. (Continued)

Plot	Materials per 100 gals.	2nd to 4th cover sprays Before	2nd to 4th cover sprays After	5th to 7th cover sprays Before	5th to 7th cover sprays After	Harvest 9/10
5B.	Same as 5 in 1st 4 covers. 4 lbs. dry mix. (Nic. 1 pt. bent. 5 lbs. mixed dry in self mixing orchard duster)	67 (4.6)	82 (8.6)	80 (2.8)	90 (4.8)	65 (1.6)
5C.	Same as 5B + 1 qt. S. Oil in last 3 covers.	"	"	89 (2.9)	93 (4.4)	78 (2.5)
5D.	Same as 5 in 1st 4 covers. Nic. 0.67 pt., Bent. 0.5 lb., M.O. 2 qts.(3 qts. in 6th cover) in last 3 covers	"	"	75 (2.4)	86 (3.3)	60 (1.4)
5E.	Same as 5 until 7th cover. Same as 5D in 7th.	"	"	86 (3.7)	94 (6.4)	84 (3.3)
6.	STM + Plaster Paris 1 lb. until 7th cover. Same as 5D in 7th.	66 (4.9)	81 (8.3)	81 (3.5)	93 (5.9)	80 (3.2)
6B.	Same as 6 except 2 qts. S. oil substituted for M.O. in 7th cover.	"	"	"	92 (6.1)	83 (3.0)
7.	Same as 5 except 1 lb. soap substituted for S. oil in all sprays	66 (4.1)	81 (7.8)	83 (3.6)	88 (5.9)	85 (3.1)
7B.	Same as 7 until 5th cover. Same as 5D in 5th, 6th, 7th.	"	"	83 (3.1)	90 (4.6)	78 (2.3)
7C.	Same as 7 until 7th. Same as 5D in 7th.	"	"	83 (3.6)	89 (5.6)	81 (3.2)
8.	Same as 7 + 2 qts. M. O.	61 (4.3)	73 (7.1)	(discontinued)		
9.	Same as 5 except 1 qt. corn oil substituted for S. oil until 7th cover. Same as 5D in 7th.	64 (4.2)	81 (8.4)	82 (3.5)	93 (5.4)	80 (2.6)

Under natural conditions the larvicidal efficiency of spray deposits on the surface of the fruit accounts for most of the control given by any of the above combinations with the possible exception of Xanthone. Comparisons based on larvicidal efficiency of treatments having similar characteristics are justifiable, but those likely to differ greatly in their ovicidal effect, degree of repellency or attractiveness to moths or larvae, the effect of deposits on the resistance of eggs to sloughing off, toxicity of sprays to adults and numerous other factors cannot be evaluated on the basis of larvicidal efficiency alone although there often are enough of these so that the effects of some balance those of others. Any such factors which affect the adult moths would reduce the reliability of comparisons of infestations made between small replicated field plots as well.

After the fourth cover spray when native larvae were hatching in very small numbers 500 newly hatched larvae were distributed at the rate of 5 per bearing fruit spur on one tree in each of 4 plots for the purpose of determining how much a combination of unfavorable weather conditions, foliage, and calyx deposits would increase actual control above that expected from the larvicidal efficiency of deposits on the fruit. All apples injured by these larvae were removed a week later.

The results follow:

Treatment	Percent larvicidal efficiency (6/20)	Injuries by 500 larvae applied June 20, one day after 4th cover.	
		Worms	Stings
Unsprayed	0 (86.4% entered)	266	193
Plot 1. LA-bdx.	60.4	2	82
" 2 Xanthone	32.9	41	162
" 5 STM.	89.9	1	12

Note: Temperatures at time of release of larvae, 72 to 74° F. Relative humidity, 35-37%. Average wind velocity, 2.6 mph. Minimum temperature next 24 hours, 50° F.

When worm entrances alone are considered the efficiency data underestimates the effect of lead arsenate more than Xanthone and Nicotine - bentenite but if stings are included the results are about as expected. Many larvae die after making stings in the field which under the controlled laboratory conditions could have survived in lead arsenate sprayed fruit. For a number of years it was observed that many of the worms that entered lead arsenate sprayed fruit in the laboratory appeared stunted when the fruit was opened 8 or 9 days later. In 1940 more than 100 8- and 9-day larvae were weighed and 84 of them subsequently reared through to the adult stage. The average weight of those alive in nicotine sprayed fruit on the 8th and 9th day was 1.35 mgs. while those which entered through lead arsenate weighed 0.76 to 0.80 mgs. At emergence adult males weighed 20 mgs. and females 29, there being no difference between spray treatments in either sex. The average time required for development from newly hatched larvae to adult was 32 days with no difference between sexes or treatments. The results indicated that

lead arsenate stopped growth for a day or so which was enough to delay an instar change, the difference in weights at 8 and 9 days being due to the fact that the instar change had already occurred in the case of the larger larvae which were subsequently nearly overtaken before maturity by the lead arsenate group. The significance of this observation is that during its first day in the apple the stunted or sickened larva may be unusually susceptible to low temperatures, which by reducing its activity still further, may cause it to drown in its frass at the point of entrance as a result of light rains, dews, or excessive juice in the apple. Such conditions would be absent or at least less prevalent in the laboratory or under those field conditions considered most favorable for development when lead arsenate frequently fails to kill and the weakened larvae are able to recover.

In Table 1, lead arsenate (Plot 1) reached its maximum efficiency near the end of the season, a characteristic occurrence with this insecticide. After drought conditions began depressing the toxicity of lead arsenate deposits early in August a spray of water alone significantly increased the efficiency despite a loss in deposit thus giving the same effect on toxicity as frequently noted after light rains. The increase was almost as much as obtained by the regular 7th cover spray but the decline thereafter was more rapid.

Micronized phenothiazine (Plot 11) as used, was the most effective material in the first-brood period ever tested here though afterits dosage was decreased to 3 lbs. per 100 gallons and the interspray intervals lengthened it was equalled by the tank-mix nicotine bentonite combinations. Three pounds of the micronized phenothiazine gave higher efficiencies and maintained larger deposits than 4 lbs. (per 100 gals.) of the regular grade (Plot 10). Because of the heavier deposits the micronized material left the fruit with an objectionable dark green color which still remains on stored fruit (Jan. 8). It affected the taste of Grimes apples and increased shrinkage in storage. The taste was flat, there being a marked reduction in sugar content. Part of the plot left unsprayed after the 4th-cover spray still retained some objectionable color at harvest. The foliage, which became almost black by mid-June, apparently suffered some reduction in rate of photosynthesis and transpiration because of the reduction in light intensity inside the trees. This may account for the reduction in size of fruit. The trees retained their foliage longer than those in other plots.

Xanthone (Plot 2), used as recommended by the manufacturer was a very poor larvicide and russeted the fruit severely. It also stunted the foliage, causing some burn. In the first-brood period its efficiency ranged from 10 to 43 percent but ovicidal tests (based on eggs deposited in the trees by caged moths) showed that it killed 72 and 73 percent of the eggs deposited 2 days before and 2 days after the 2nd and 3rd cover sprays whereas the Plot 1 combination of lead arsenate-oil-bordeaux killed 31 percent deposited before sprays and 11 percent of those deposited afterwards. Mineral oil with nicotine bentonite (Plot 8) at the same time killed only 10 percent. During longer interspray periods later in the season or when there was much rain or wind the larvicidal efficiency of Xanthone declined to zero. No chemical analyses were made but its susceptibility to weathering was very apparent.

Beginning 4 days before the 6th cover and continuing until August 11, 4 days after the 7th cover spray 4 cages of moths were maintained in the tops and bottoms of trees in Plots 2 and 5-D (mineral oil-nicotine sulfate). These were changed to new locations and fresh moths introduced at 2-day intervals. They were removed temporarily when sprays were applied. The small tagged branches containing fruit and foliage on which eggs were deposited were rarely visible to the spray men. They were removed when the first eggs deposited at each position were 5 days old and beginning to hatch. The examination for mortality was delayed another 5 days or more while the eggs were protected from wind and rain (to prevent loss) but were subjected to other outdoor conditions. Mortality among the 11 lots of eggs deposited over the 22 day period in Plot 2 ranged from 11.8 to 52.8 percent. Of 21,400 eggs observed in the plot 32.5 percent were killed while only 23.8 percent of 13,400 deposited during the same period on Plot 5-D were destroyed by the oil-nicotine. Xanthone was most toxic to eggs deposited on top of fresh deposits, oil-nicotine was most toxic when applied over eggs about to hatch. Xanthone was more effective against eggs on the upper than on lower surface of leaves (more visible deposit there) and on leaves than on fruit while oil-nicotine was equally effective on both surfaces of leaves but more effective on fruit than foliage. It is probable that eggs deposited on top of Xanthone residue tied down a toxic layer and thus weresubjected for a longer period to more residue than eggs deposited before a spray on the weathered surfaces. The Xanthone permitted few worm or sting injuries on the plot until the second-brood period apparently because of the ovicidal effect and short interval between sprays. It failed later when the spray interval was lengthened to two weeks and optimum temperatures reduced the incubation period to 5 or 6 days. In combination with bordeaux mixture, Xanthone russeted 100 percent of the fruit surface. The injury was becoming evident before the 2nd cover spray. The increase in efficiency where bordeaux was used was believed due to the retention of more material on the roughened fruit surface.

Plots 4 and 4-A (factory-processed nicotine bentonite) were inferior to the standard tank-mix nicotine bentonite soybean oil combination (Plot 5).

No improvement on the latter is evident among the results of the other combinations tested. The "dry-mix" nicotine sulfate-bentonite (1 pt. nicotine sulfate to each 5 lbs. powdered bentonite mixed thoroughly in a self mixing orchard duster) avoids the excessive heavy visible deposits obtained when the ingredients are tank mixed but was slightly less efficient where used with soybean oil and considerably so at harvest when used alone. Greater differences could be expected under conditions of normal rainfall but the avoidance of residue difficulties at harvest, and of some objectionable effects of mineral oil where oil-nicotine is used to complete the tank-mix schedule, together with the evidence that its larvicidal efficiency may exceed that of mineral oil-nicotine sulfate (5-D) enough to make up for its deficiency as an ovicide make it a promising material for further investigation.

Excessively hard water (artifically hardened) did not affect the performance of the "tank-mix". Corn oil proved an effective substitute for soybean oil for the second season, although of no advantage at present prices.

Sodium oleate at a dosage properly adjusted to water hardness to give the same type of flocculation as obtained with soybean oil proved an effective substitute for soybean oil although it is less safe for the average grower to use because past experience has demonstrated that either too much or too little soap will reduce efficiency. In Plot 8 the use of mineral oil was again tested but although the soap smoothed the deposits somewhat a definite reduction in efficiency resulted.

The nicotine combinations caused no injury although where the effects of the moisture deficiency were most evident the trees began losing leaves in late August. This loss coincided almost exactly and was similar in all respects to the partial defoliation of trees not sprayed after petal-fall. All plots which received copper compounds in one or more sprays, copper-nicotine included, as well as the Xanthone-zinc sulfate and phenothiazine plots held most of their foliage through October although Plot 1 lost some in August. Weather conditions were not favorable to the production of arsenical injury.

Analyses of lead residues were made by the Division of Insecticide Investigations at harvest before and after Grimes fruit from the lead arsenate sprayed plots was washed. The fruit was washed in a Cutler underbrush machine for 30 sec. using 1.5% HCl at a temperature of 70° F.

	Grains Pb per lb. fruit	
	Before washing	After washing
Plot 1 Lead-oil-bordeaux	0.219	0.026
Plot 1A (no second brood sprays)	.102	.020
Plot 11-D Micronized phenothiazine first 4 covers; same as 1 later	.154	.019

As in previous years lead residues from late sprays were more easily reduced by washing than those from first-brood sprays. Four first-brood lead arsenate sprays resulted in harvest residues about twice those permitted by the new Federal tolerance.

Tests of New Materials

Laboratory-field efficiency tests of several new materials were made but such tests were confined to relatively short periods and limited to from one to three sprays.

Among the materials tested Phenazine had the highest initial toxicity but declined rapidly and produced serious injury to both trees and spraymen.

The factory processed nicotine-bentonite was improved by micronizing it. Preliminary tests indicated that its toxicity and the amount of material deposited were both increased as was the visible residue at harvest.

Lei kung t'eng gave efficiencies up to 41 percent and can be considered promising if the roots can be ground into a condition suitable for use in spray mixtures.

Efficiency of calyx sprays

Since experiments in 1939 proved that the majority of early first-brood larvae attempt entrance at the calyx and it is known that the progeny of these early larvae constitute most of the third brood, a check on the efficiency of the spray combinations recommended for use as petal-fall sprays seemed desirable. The value of phenothiazine and Xanthone as calyx sprays were also determined. The lead arsenate sprays were varied so that a deposit building combination could be compared with those containing spreaders. The use of the latter has been advocated by some, the theory being that a wetting agent was needed to penetrate into the calyx cup.

Single tree plots replicated 3 times were arranged in a block of mature Winesap trees which received no other sprays.

The sprays were applied on May 8. Because Winesap trees set a very light crop it was necessary to strip all of the fruit from some of the trees in order to obtain an adequate sample for the determination of the infestation on June 28. Stratified samples of 200 fruits were taken from the other trees. Analyses of As_2O_3 were made by the Insecticide Division.

The results are given in Table 2.

Table 2. Efficiency of Calyx Sprays. Vincennes, Indiana. 1940
(Sprays applied May 8, infestation determined June 28.)

Plot	Treatment	No. apples examined	No. per 100 apples		Percent of worms entering thru calyx	Deposits in mmg. per apple May 9.
			Worms	Stings		
Check	Unsprayed	600	43.3	3.7	64.2	0
1	Xanthone 3 lbs. Sodium oleate 1 lb. Zinc sulfate 4 1/2 ozs.	580	24.4	4.1	54.8	0
2.	Phenothiazine 4 lbs.	487	25.5	4.1	38.1	Pheno. 72.5
3.	Lead arsenate 3 lbs. Lime 3 lbs. Flotation sulfur paste 12 lbs.	511	16.1	9.8	4.0	As_2O_3 55.9
4.	Lead arsenate 3 lbs., Lime 3 lbs., Wettable sulfur 8 lbs.	600	21.7	15.2	1.3	43.6
5.	Same as 4 plus 1 pt. Nicotine sulfate (40%) and 1 lb. sodium oleate	543	20.4	10.3	2.1	39.4
6.	Same as 5 except 2 lbs. soybean flour substituted for sodium oleate	598	16.8	17.3	1.5	39.1
7.*	Lead arsenate 3 lbs. Summer oil 2 qts. Pine tar soap 1 lb.	523	12.9	8.9	1.8	39.1

*Deposit building formula. Trees were given the same amount (23 to 28 gals.) as other plots. It was necessary to add lime to this formula while spraying the 2nd and 3rd trees to prevent breaking in the tank.

The most important data in Table 3 are the percentages of worms which entered through the calyx. The differences among the lead arsenate treatments were not significant, although Plot 3 with no wetting agent appeared least effective yet it held the most As_2O_3. Phenothiazine was partially effective but neither it nor Xanthone were of any practical use. The larger number of stings on the lead arsenate plots indicates that enough poison remained on the surface and on foliage to effect some kill. The results indicate that there was no loss in efficiency from the use of supplements that result in greater wetting ability. There was, however, a significant reduction in amount of As_2O_3 deposited.

Effects of spray materials on adult moths:

The effects of the spray treatments on caged adult moths were tested in the field, and preliminary tests were conducted in the laboratory in an effort to determine if mortality from fixed nicotines is increased by feeding of the adult when wet by the spray. Nicotine sulfate was very effective in killing both by contact and by ingestion. The tank-mix combination killed some moths by contact but moths could feed on it without any immediate effect. Life was shortened to that of moths which received nothing. Moths with probosces removed apparently took small quantities of the solutions by placing the head in close contact with the feeding surface. Newly emerged moths offered one feeding of distilled water took an average of 2.94 mgms. and lived 6.9 days. Those offered nicotine sulfate solution (1-800) took only 1.00 mgm. and lived an average of 1.8 days while those offered the tank-mix solution took 2.10 mgms. and lived 6.1 days. Unfed moths lived 6.7 days, thus one initial feeding appeared inadequate. Moths given water every one or two days after their first feeding on nicotine sulfate lived an average of 0.6 day, those fed nicotine-bentonite first, lived 12 days with a maximum of 22 days, those fed nothing but water also averaged 12 days but the maximum record was 34 days. Moths consumed the equivalent of their weight in water over a 20 day period.

Under orchard conditions nicotine-bentonite-soap sprays killed or completely paralyzed 50 percent of the caged moths, the same plus mineral oil so affected 42 percent, standard tank-mix 36 percent, phenothiazine and lead arsenate-oil each about 28 percent, and Xanthone only 17 percent.

Large-scale and small plot field tests.

Through the courtesy of the W. C. Reed and Son Orchard Company we were able to compare the results from the commercial use of the tank-mix nicotine bentonite soybean oil and heavy lead arsenate-oil programs for the 4th consecutive year. These experiments were supplemented by laboratory-field tests and by studies on development and abundance as well as by chemical analyses of deposits, the latter by the Division of Insecticide Investigations.

Because of a light set of fruit on some varieties the south nicotine area used in 1938 and 1939 was reduced to 11 acres and the lead arsenate schedule was applied to all parts of the orchard except this block and the north nicotine area of 16 acres. The regular lead arsenate block of 17 acres located between the two nicotine areas was used for the comparisons.

All spray materials used in the large experiment were furnished and applied by the Company through a stationary plant. Information obtained from 40 bait traps, several emergence cages, and the weekly fumigation of 10 trees was made available to the Company to aid in timing sprays, but because of a light crop, low prices for fruit, and the necessity for conserving funds the intervals between the midseason sprays were lengthened. This resulted in a heavy infestation in both areas since weather conditions after early June were highly favorable for development and the attack continued into early October.

The moth population appeared largest in the area sprayed with lead arsenate where the traps caught an average of 489 moths, and 17 fumigations of 5 scattered trees yielded 400. In the areas sprayed with nicotine the traps averaged 368 moths and 323 were knocked down by the 17 fumigations of 5 trees. Fifty-two percent of the moths found while fumigating the trees were females.

After petalfall the lead arsenate program consisted of a first cover of lead arsenate-weak bordeaux mixture, a 2nd and 5th of lead arsenate with a commercial deposit builder, 3rd and 4th of lead-oil-soap "dynamite" combination, 6th and 7th lead arsenate-oil-bordeaux mixture and 8th on August 19 of 0.7 gal. mineral oil per 100 gallons. The tank-mix nicotine bentonite program consisted of a 1st cover spray of 1 pt. nicotine sulfate (40%), 5 lbs. bentonite and 6 lbs. sulfur (per 100 gals.), and 2nd to 7th covers inclusive of 1 pt. nicotine sulfate, 5 lbs. - bentonite and 1 qt. soybean oil, an 8th cover of 0.7 gallon mineral oil on August 19 like that applied to the lead arsenate area and a 3rd-brood spray on September 5 of 0.7 pt. nicotine sulfate and 0.6 gallon mineral oil.

The total number of gallons of spray material applied per tree after petalfall (exclusive of a "hormone" spray applied to the lead arsenate area at harvest) approximated 177 gallons of the lead arsenate mixtures and 180 gallons of the nicotine combinations at average costs for materials alone of $0.94 and $1.53 per tree for the two treatments respectively.

On June 30 the average infestation for 4 varieties (Grimes, Jonathan, Rome Beauty, Starking) was as follows:

Treatment	Number per tree			Percent of apples clean
	Apples	Worms	Stings	
Nicotine	3,070	83	152	91.6
Lead arsenate	3,052	108	354	85.4

These examinations included stratified samples of 200 apples in addition to the drop fruit from each of 98 trees.

The average infestation for the season on the same trees was as follows.

Treatment	Number per tree			Percent of apples			Percent of wormy apples entered at calyx*
	Apples	Worms	Stings	Clean	Wormy	Stung	
Nicotine	3,070	775	326	67.9	26.1	9.7	31.8
Lead Arsenate	3,052	782	1,130	57.0	27.3	26.2	17.5

* Within rim of calyx cavity, adjacent to or through calyx.

The slack in the spray program in mid-season and the failure to spray or remove all wormy apples from 40 percent of the trees at the west end of the two nicotine areas (because of their light crop) made bearing varieties in these areas subject to more late migration than the lead arsenate area. There was also evidence that migration from these light-bearing trees resulted in a concentration of spring-brood moths on some of the Rome Beauty and Starking blocks included in the examinations and on a single row of Grimes surrounded by the light-bearing trees. On June 30 these Grimes had only 60.5 and 59.4 percent clean fruit where sprayed with nicotine and lead arsenate respectively and at the end of the season only 31.5 and 32.6 percent.

Both nicotine and lead arsenate programs were heavier late in the season than generally used and were made necessary by the mid-season let up, however, the extra cost of the nicotine was offset by the reduction in stung fruit, control of worms being equal. In a season with normal rainfall severe injury would be expected from a lead arsenate program such as used in 1940. Samples taken on September 17 and washed in an underbrush machine for 30 sec. in 1.5% HCl (by weight) at 70° F. retained lead residues either very close to or in excess of the new tolerance. Grimes retained 0.101 grs. Pb. per lb., Jonathan .049, Rome Beauty .046 and Starking .054.

As in the past the least improvement in control was obtained on Grimes and the most on Jonathan but the large Grimes yields made the use of nicotine most profitable on that variety.

In small-plot tests a first cover spray of lead arsenate-weak bordeaux mixture followed by 3 heavy deposit-building sprays of lead arsenate-oil-soap (the last in mid-June) resulted in a first-brood infestation of 12 worms per tree compared with 38 on 2 regular tank-mix nicotine bentonite soybean oil plots. The former was sprayed with an average total of 151 gals. of material per tree, but received no subsequent sprays. Its larvicidal efficiency steadily increased from 50 percent after the 2nd cover spray to 98 percent after the 4th with gains instead of losses between sprays. Deposits of As_2O_3 declined between sprays but approximated 30 mmg. per sq. cm. after the 4th cover spray. Lead residues at harvest averaged 0.124 grs. per lb. of fruit. The nicotine plots received an average of 106 gallons per tree prior to June 30 and one received an additional 94 gallons in the 2nd-and 3rd-brood periods. At harvest the lead arsenate plot averaged 2,555 worms and 3,417 stings per tree with only 26.5 percent of its fruit clean while the nicotine plot averaged 900 worms and 314 stings per tree and produced 49.2 percent clean fruit. The results show conclusively that a heavy lead oil-soap schedule may almost annihilate the first brood but will not give adequate protection against late 2nd- and 3rd-brood worms if the trees are subject to reinfestation by migrating moths. In this series of tests reductions in the amounts of the tank-mix nicotine bentonite soybean oil resulted in a slightly heavier infestation when the number of gallons was reduced one third, than where the trees were drenched with the normal amount but the reduction made by diluting the solution to two-thirds normal strength.

These two plots averaged 149 and 125 worms per tree respectively at the end of June.

Laboratory-field tests showed that it was possible for the grower to more nearly approximate our results with nicotine bentonite than with lead arsenate during the early part of the season. Although he maintained as heavy deposits of nicotine in the tops of the trees early in the season as in the lower parts, deposits on the lower fruit gave a higher average efficiency and on June 30 the actual worm infestation on Rome Beauty was 4 times as great in the tops as in the bottoms. In the lead arsenate area both deposits and efficiencies were smallest in the tops yet only twice as many worms were present there. For all varieties the ratio of top to bottom worms per 100 apples varied from 0.6: to 2.6: 1 in the north nicotine area, 2.3 to 5.5: 1 in the south nicotine and 0.5 to 2.3: 1 in the lead arsenate blocks with the largest ratio in the sections subject to the most migration suggesting that migrating moths may oviposit more heavily in the tops and (since the nicotine deposits on fruit were the same in top and bottom of certain Rome trees) that the heavier and more evenly distributed deposits of bentonite on foliage in the bottoms of trees sprayed with nicotine may have been more repellent to ovipositing females or have made eggs deposited there more susceptible to mechanical removal by rain or leaf brushing. The need for a special top-off spray (preferably in early June) on the upper third of trees sprayed with nicotine-bentonite is evident from these data.

One of the most important developments of the large scale tests were the differences in size of crops. In 1939 the average yield in the nicotine area increased over that of 1938 but in the lead arsenate area it decreased and greatly widened the difference originally shown in 1938. The average yields for the same 43 Grimes, Starking and Rome Beauty trees used each year were as follows.

	No. apples per tree		
	1938	1939	1940
Nicotine area ----------	3,390	3,784	3,567
Lead arsenate area ----------	2,938	2,718	3,477

Yields in 1939 were thought to have been reduced by arsenical injury which occurred in 1938. The difference in 1938 may have been a coincidence since the areas were treated alike in 1937, or may have been caused by the 1938 spray program.

Great differences in yields such as in 1939 would normally be followed the next year by a reduction on the high yielding trees and an increase on the low yielding trees. Observations in 1940 indicated that the first cover spray may be partly responsible. (This is the only one which could affect the current crop since all apples falling after the second cover are counted as part of the crop). Between May 21 and 31, Grimes sprayed with lead arsenate weak bordeaux mixture lost approximately 39.5 percent of the apples present on the first date. Grimes sprayed with nicotine sulfate bentonite and sulfur lost 32.4 percent. The lead arsenate trees had about 600 more apples to begin with than the nicotine but 250 less afterwards. Rome Beauty and Starking in the lead arsenate area lost 49.5 and 12.5 percent respectively

while in the nicotine areas they lost 38.7 and 9.9 percent. That heavy applications of nicotine-bentonite and flotation sulfur can also reduce the set is indicated by an apparently significant reduction in yield on the small Rome Beauty nicotine plots compared with the lead arsenate-bordeaux, and lead-oil-soap plot and the areas sprayed by the grower. The danger from late use of sulfur is generally recognized but lead arsenate supposedly safened by weak bordeaux mixture is considered one of the safest combinations. A fungicide was necessary at the time of the first cover spray to check apple scab.

For four successive years the tank-mix nicotine bentonite soybean oil program as used in this orchard has at least paid for its increased cost in better control of codling moth alone. In one Kentucky orchard where annual heavy losses have occurred from codling moth under lead arsenate programs, 5 tank-mix nicotine sprays properly timed and thoroughly applied resulted in the production of more than 85 percent U.S. No. 1 fruit; more bushels of No. 1 than produced by the orchard in all the preceding 5 years according to the grower.

The need for a fungicide that is compatible with nicotine-bentonite and that will control bitter rot without decreasing efficiency of the insecticide is as great as ever.

Spray Injury Experiments

A comprehensive series of injury tests was conducted using young Jonathan trees. The treatments consisted of 4 different early fungicide programs on each of which 11 different cover spray programs were used. The object was to determine the reason for the "frog-eye" type of leaf spotting generally associated with marginal and tip burn that has been serious on some varieties sprayed with nicotine-bentonite and mineral oil- nicotine sulfate sprays during the past few years. Though somewhat similar to black rot or "frog-eye" injury, pathologists who have observed the injury do not identify it as a disease.

Although the tank-mix program was applied to one plot five times at double strength (1 qt. nicotine sulfate, 10 lbs. bentonite, 2 qts. soybean oil per 100 gals.), the last on July 23, the injury described above appeared in very slight amounts on only a few of the trees while it became very severe with nearly all leaves affected on trees which received no cover sprays. It was also present on factory-processed nicotine bentonite-mineral oil plots. It was absent where lead arsenate bordeaux had been used and was scarce on trees that had received a 7-day cover spray of lead arsenate flotation sulfur but no subsequent sprays. The injury progressed until July, remaining most severe on the plots not sprayed after petalfall and least severe or absent where lead arsenate-bordeaux or heavy bentonite deposits were present. In August it suddenly flared up on the above mentioned trees that received no sprays after the 7-day lead arsenate-sulfur application. The results suggested that both fungicides and heavy bentonite deposits applied soon after the petalfall period checked the injury. They proved conclusively that it was not caused by the nicotine-bentonite combinations.

BAIT TRAP EXPERIMENTS

Bait traps were operated in 4 orchards for the purpose of comparing the relative attractiveness of different formulas over long periods, of determining the control value of traps, and as aids in timing sprays and measuring population differences. Traps were maintained in 612 trees, those in 290 being examined periodically. These latter caught approximately 50,000 moths during the season.

Relative Attractiveness of Different Baits

The double quart-jar type of trap with solutions changed completely in alternate halves of the trap at 10 day intervals was employed in all except one experiment.

Old vs. fresh sugar: Traps used primarily for timing and population studies were baited with a 10 percent solution of dark brown (No. 13 soft) sugar containing oil of sassafras (Nat.) and sodium arsenite, 0.5 cc. and 0.5 gm. respectively per quart.

Since there is frequently a considerable difference in color and condition between old and new sugar of the same color number, No. 13 sugar held over from 1939 was used for the bait in the odd numbered traps and new sugar was used in the others.

The results follow:

	Average number moths per trap				
	May and June	July	August	September	Total
1939 sugar	104.2	95.6	135.3	71.7	406.8
1940 sugar	107.4	104.4	135.2	77.8	424.8

The difference is not significant.

Traps hung from limbs vs. traps on supports: In most instances mature trees in this region have high, nearly horizontal branches near the center of the tree from which traps can be hung so that it has been questionable whether we could improve on position by the use of 2" x 2" poles to support the trap. Such supports, however, are necessary in many young trees.

Ten mature trees were used for this experiment. Traps contained the same bait but were rotated within each tree between the two positions twice weekly. In each case the best available location was selected so that in some trees the trap on the support and that on the limb might happen to be close together and in others far apart.

The results follow:

	No. moths per trap
Traps on 2" x 2" supports near top of foliage	230.7
Traps hung from highest limb	232.5

The catches were similar from month to month, hence either method is satisfactory. The second, however, is cheaper but because of changes in limb position, relocation of some traps are necessary each year.

Comparison of experimental baits: Baits were compared by the rotating method in 3 series of 4 or 6 baits each. Each bait was replicated 8 or 9 times. The standard bait (No. 1 in Table 3) was repeated in each series.

The May and June and the July, August, September catches are combined in Table 3. Some of these baits, however, can be properly compared only by considering their relative effectiveness within specific intervals during the season since baits most effective in one type of weather may be least effective under another set of conditions.

Table 3. Average number of codling moths captured per trap in experimental baits. Vincennes, Indiana. 1940.

10% dark brown sugar stock solution to each quart of which the following were added	D - 1		D - 2		D - 3	
	May & June	July to Sept.	May & June	July to Sept.	May to June	July to Sept.
1. 0.5 cc. oil of sassafras (Nat.) 0.5 gm. sodium arsenite	23.6	66.6	41.5	123.4	83.1	130.9
2. 0.5 cc. bromostyrene 1 cc. nicotine sulfate	26.1	98.9				
3. 0.5 cc. oil of sassafras (Nat.)	25.2	43.3				
4. 0.5 cc. bromostyrene	19.9	65.4				
5. 0.5 cc. oil of sassafras (Nat.) 0.25 gm. sodium arsenite			45.4	112.4		
6. 0.5 gm. sodium arsenite			20.7	74.8		
7. Sugar alone			27.5	52.4		
8. 0.5 cc. oil of sassafras 1 cc. nicotine sulfate			47.1	100.0		
9. Duplicate of 8 until July 1. " of 1 later.			43.8	114.5		
10. 0.5 cc. bromostyrene 0.5 gm. sodium arsenite					59.5	176.3
11. 0.25 cc. bromostyrene 0.5 gm. sodium arsenite					71.8	173.1
12. 0.5 cc. oil of mace 0.5 gm. sodium arsenite					98.2	118.0
14. 0.5 cc. oil of anise 0.5 gm. sodium arsenite					69.8	88.3

Least significant difference	Odds 1%	6.7	19.5	10.2	22.9	13.8	27.1
	5%	9.0	14.4	13.6	17.0	18.4	20.2

As an example of the effect of weather conditions, Bait 3 in Series D-1 was significantly more effective than Bait 1 in May which was cool while the reverse was true in June and later months. The use of sodium arsenite in cool weather decreased the catches but in hot weather it increased them. Bromo-styrene ("bromo-styrol") proved to be the outstanding hot weather bait when supplemented by nicotine sulfate or sodium arsenite. (Baits 2, 10, and 11).

Relative attractiveness of baits to Fruit Tree Leafroller Adults

Since the leafroller problem has become acute in western Illinois bait traps may be worth considering in the control program for this pest. For a number of years heavy catches of leafrollers have been made in our codling moth traps in June.

From June 19 to 29 during the latter part of the flight period (which began June 3), the moths captured in the Series D baits were counted.

The only outstanding leafroller bait in D-1 (Table 3) was No.2. Nos. 6 and 7 were significantly superior to the others in Series D-2. The most effective appeared to be No.11 in D-3 which caught an average of 67 moths or nearly 5 times as many as Bait 1 while Nos. 2, 6, and 7, caught only about twice as many. Baits containing oil of sassafras were less effective than sugar alone hence this aromatic may be somewhat repellent. The leaf-rollers were caught late in June after the decline in codling moth abundance hence it could not be determined if those baits most attractive to one insect would also have been most attractive to the other at the same time.

The Control Experiment

A rectangular 30-acre section of an orchard which was well sprayed in 1939 but poorly cared for in 1940 was used to test the value of bait traps when used as a control measure. In 1939 the west 15-acre half was trapped and the east used for the check. In 1940 the traps were moved into the east half and the west block used as the check. An unsealed packing shed was located beside the area baited in 1940 near its junction with the unbaited area. Both areas were subject to its influence but the east area was affected the most. The treatments were reversed in 1940 because the normal distribution of the population was unknown and a two-year test on this basis offset in part the lack of replication. It of course put the baits at a disadvantage because to show any apparent control in 1940 they had to first overcome the differences built up in 1939.

In 1940, Baits 1 and 2 (Table 3) were distributed in alternate pairs of rows, 390 trees being baited. Two double-traps were used in a few trees near the packing shed and along the border of an unsprayed young orchard on the east. Series D-1 (Table 3) was set up in the two rows adjoining the unbaited area. Because the baits were not disturbed for long periods

(3 to 4 weeks) it was found in July that a tight scum was forming on Bait 2 (bromostyrene-nicotine sulfate-sugar) and reducing its effectiveness. Bait 11 (bromostyrene-sodium arsenite-sugar) was therefore substituted for Bait 2 on August 2. In the traps containing Bait 2 from which moths and larger insects were removed 3 or 4 times weekly no objectionable scum formed.

The fruit on 13 Winesap and 13 Rome Beauty trees in each area was examined. The data are given in Table 4.

Table 4. Average Infestation on Winesap and Rome Beauty trees in baited and unbaited areas. Vincennes, Indiana. 1940

	Average number per tree				Percent of apples		
		Worms					
Plot	Apples	June 30	Season	Stings	Clean	Wormy	Stung
Baited	946	96	762	297	43.8	46.2	21.4
Unbaited	1,104	93	1,151	428	33.6	54.2	29.4

In 1939 the east area averaged 3,841 apples per tree compared with 3,174 in the west area. The difference in yields between the areas was reversed in 1940 but the advantage in size of crop remained with the unbaited area. The baits in 1939 appeared to have reduced the worm population about 71 percent, from 436 to 126 worm entrances per tree. In 1940 therefore the baited area had overcome this difference by the end of June despite its proximity to the packing shed and by harvest had caused a further reduction in number of injuries per tree of approximately 32 percent. If allowance is made for the effect of differences in yields, the true difference in infestation will fall around 25 percent. In previous years we have found that baits appear most effective in the first-brood period, for example by June 30 of 1939 the apparent reduction was 79 percent so that some of the control gained was lost before harvest. The areas of 15 acres are too small to retain early gains if these gains establish relatively large differences, the overflow of moths from untreated to treated blocks tending to reduce the rate of increase in one area and increase it in the other. For the first time in several years a substantial further reduction was made after June 30 partly because the baits were not handicapped by a large population difference in midseason. Likewise the tendency for the two 1939 populations to level off probably aided the baits in overcoming their initial handicap.

Traps in the area caught approximately 4,500 spring-brood moths and 12,860 of the 1st and 2nd broods. That the packing shed supplied many during the period in June when emergence reached its peak in the shed is indicated by the fact that 63 percent of the spring-brood moths were caught in June whereas in other orchards only 45 percent were caught in that month.

Orchard Sanitation

Additional sanitation studies again showed that some overwintering

larvae move to new quarters before pupation in the spring. A detailed examination of 11 trees and three 20° sectors under each showed that 25 percent of the surviving population was on the ground. Most of these larvae were in weed stems, some in straw mulch, and a few in leaves, bits of wood, brier stubble and on small twigs. Of those on the ground 54 percent were within 3 ft. of the trunk (an unusually high proportion for this region), 38 percent were from 3 to 10 feet away, and 8 percent were more than 10 feet.

BELTSVILLE, MARYLAND

E. H. Siegler, In Charge

General Insecticide and Foliage Tests

Much of the work at this laboratory consists in the toxicological evaluation of organic compounds. The results of these tests are usually reported under code numbers and, therefore, would have no special value to the reader at this time. There are certain data, however, which may be of interest and these are herewith reported.

A considerable number of small-scale tests of new organic insecticides alone and in combination with fungicides have been made on apple and peach foliage in cooperation with the Bureau of Plant Industry of the Department of Agriculture. The effectsof these sprays were observed. The results are fairly indicative of that which may be expected, especially in instances in which damage to the foliage occurred. In these cases it is believed that the materials are rather definitely eliminated as potential sprays; on the other hand, the sprays which caused no injury are worthy of further study.

Phenazine has been tested at this laboratory from time to time. The last test gave a very low percentage of wormy plugs (3.3), but a high percentage of stung fruit (48.9), which results are more or less characteristic of this compound.

Compound E - 1359 (para nitrophenyl iodochloride) gave only 2 percent of wormy plugs. When tested as a spray on Stayman apple foliage it gave slight injury, and moderate injury to the foliage of Grimes Golden. When combined with Bordeaux mixture, slight injury resulted to Grimes Golden. This compound was also tested on the foliage of Elberta peach trees. When used alone it produced severe injury, but when combined with wettable sulphur and hydrated lime it caused no injury to the peach foliage. An isomer of the above compound, coded as E - 1357 and identified as ortho nitrophenyl iodochloride, was also very effective with respect to preventing successful entrants, but permitted 51.9 percent of stings. On Stayman foliage this compound produced very slight injury and on Grimes foliage no injury when used alone or when employed with Bordeaux mixture. However, sprays of this compound alone and combined with wettable sulphur plus hydrated lime were severely injurious to Elberta peach foliage.

When used at a concentration of 0.05%, the alkaloids anabasine and lupinine are relatively non-toxic to codling moth larvae.

It has been found by plant pathologists of the Bureau of Plant Industry of the U. S. Department of Agriculture that the addition of ferric chloride to phenothiazine gives a higher fungicidal value than when phenothiazine is used alone. The results of a test indicated that the addition of ferric chloride lowers somewhat the effectiveness of phenothiazine against codling moth larvae. The Division of Insecticide Investigations

suggested that possibly the addition of lime to the combination of phenothiazine-bentonite would prevent the unfavorable action of bentonite on the toxicity of phenothiazine. Tests conducted showed that lime increases the initial toxicity of phenothiazine and that it prevents the rapid loss in the toxicity of the insecticide in the presence of bentonite. Also it was found that lime improves somewhat the initial toxicity of the combination of phenothiazine-bentonite.

In view of the helpfulness of lime in preventing the quick loss in toxicity of phenothiazine-bentonite, a study of the residual effectiveness of lime in this connection was made. The sprayed fruit was held in a greenhouse for a week previous to infestation. The resulting data indicated that lime does not prevent, except for a day or so, the breakdown in the toxicity of phenothiazine in the presence of bentonite.

Because of the value of lime-sulphur solution as a fungicide tests were made in which it was combined with phenothiazine. The toxicological results of the test indicated that lime-sulphur does not have the same effect as lime in increasing the initial effectiveness of phenothiazine.

According to results obtained with a combination of phenothiazine and wettable sulphur, either alone or plus lime, it appears that the addition of these materials considerably lowers the initial toxicity of this compound.

Three samples of phenothiazine, prepared from crystalline, amorphous, or mixed crystalline and amorphous sulphur (50% of each), were tested to determine what, if any, effect the structural form of the sulphur would have on the toxicity of the compound. The results of these tests showed that toxicities of the three samples to newly-hatched codling moth larva were about the same.

The Thunder God Vine, An Insecticide-bearing Plant

History

Chinese market gardeners have long used the powdered roots of the Thunder God Vine, (lei kung teng), Tripterygium wilfordii, Hook fil., for insecticidal purposes. Recently it has been introduced into Maryland for the study of its growth and possibilities as an insecticide plant.

Chemical and toxicological studies

In cooperation with the Division of Insecticide Investigations, this laboratory has made a preliminary evaluation of the toxicities of the roots and of various extracts. The chemical studies have largely followed the leads furnished by the toxicological results. At the present writing, however, the nature of the toxic component or components are undetermined. But irrespective of the poisonous materials which are contained in the roots of this plant, our results show them to be highly toxic to codling moth larvae. How practical it would be to extract the poisonous substances for

commercial usage is not yet known. If, on the other hand, the insecticidal principles could be synthesized, this method of preparation might offer more promise than the making of plant extractives from the standpoint of commercial production.

The results of laboratory tests against newly-hatched codling moth larvae are given in Table 1. As a matter of comparison the reader will be interested in knowing that the average of all lead arsenate (2-50) tests made during 1940 was 33.7 percent wormy, 13.0 percent stung, and 53.3 percent of clean apple plugs, and that the average of all check tests was 92.3, 0.4 and 7.3 percents of wormy, stung and clean plugs, respectively.

Attention is called to the fact that the insecticidal constituents are present in the alkali insoluble fraction, designated as 547. It is of further interest to note that extractive L -115 retains its toxicity after a week's exposure as a spray film under laboratory conditions.

One serious weakness has thus far been discovered with reference to extractive L - 115. In simultaneous tests this gave 3.9 percent of wormy plugs when used alone, but when combined with Bordeaux mixture and with wettable sulphur plus hydrated lime, the percents of wormy plugs were 84.9 and 69.9 respectively.

Other variations in results, due to chemical preparation, will be noted in the data for different extracts as shown in Table 1.

Table 1.--Results of laboratory tests against codling moth larvae of various samples obtained from the roots of Thunder God Vine (Lei Kung t'eng) Tripterygium wilfordii. Local larvae.

Sample and dosage		Date of test	No. Plugs	Percentage		
				Wormy	Stung	Clean
Small roots	2-50	Oct. 1939	94	43.6	9.6	46.8
Medium-sized roots	2-50	Oct. 1939	100	41.0	11.0	48.0
Extractive No. 6	4-50	Nov. 1939	85	1.2	1.2	97.6
Large-sized roots (200 mesh or smaller)	2-50	Feb. 1940	101	36.6	1.0	62.4
Medium-sized roots (200 mesh or smaller)	2-50	Feb. 1940	103	40.8	3.9	55.3
Alcoholic extractive A-102 of very fine roots	2-50	Mar. 1940	102	6.9	1.0	92.1
Alcoholic extractive A-103 of bark of medium-size fresh roots	2-50	Mar. 1940	102	1.0	3.9	95.1
Water soluble fraction of alcoholic extractive A-104 of medium-size fresh roots without bark	2-50	Mar. 1940	97	52.6	3.1	44.3
Alcoholic extractive A-105 of medium-size fresh roots	2-50	Mar. 1940	94	2.1	1.1	96.8
A-106 Root from China (100 mesh or smaller)	2-50	Mar. 1940	102	22.5	1.0	76.5
546, Alkali soluble fraction of A-102, A-103 and A-105	2-50	Mar. 1940	102	86.3	0.0	13.7
547, Alkali insoluble fraction of A-102, A-103 and A-105	2-50	Mar. 1940	99	0.0	17.2	82.8
548, Ether insoluble gum from A-102, A-103 and A-105	2-50	Mar. 1940	32	78.1	0.0	21.9
556, Extractive of 107	½-50	May 1940	98	9.2	6.1	84.7

Table 1.--Results of laboratory tests against codling moth larvae of various samples obtained from the roots of Thunder God Vine (Lei Kung t'eng) Tripterygium wilfordii. Washington larvae. (cont.)

Sample and dosage		Date of test	No. plugs	Percentage Wormy	Stung	Clean
L-113 extractive	2-50	Oct. 1940	102	19.6	17.7	62.7
L-114 extractive	2-50	Oct. 1940	101	10.9	11.9	77.2
L-115 extractive	2-50	Oct. 1940	104	1.0	11.5	87.5
L-115 extractive Whole apple residual test sprayed Nov. 12 and infested Nov. 19	2-50	Nov. 1940	109	16.5	16.5	66.0*
L-115 extractive Whole apple residual test sprayed Nov. 19 and infested Nov. 19	2-50	Nov. 1940	107	9.4	22.4	68.2
L-115 extractive	2-50	Nov. 1940	103	3.9	5.8	90.3
L-115 extractive + Bordeaux	2-50 2-4-50	Nov. 1940	99	84.9	1.0	14.1
L-115 extractive + Wettable sulfur (Sulfuron) + Hydrated lime	2-50 3-50 3-50	Nov. 1940	103	69.9	2.9	26.2**
L-115 extractive	2-50	Nov. 1940	106	12.3	11.3	76.4
L-115 extractive Whole apple residual test sprayed Nov. 28 and infested Dec. 5	2-50	Nov. 1940	106	16.0	25.5	59.5
L-115 extractive Whole apple residual test sprayed Dec. 5 and infested Dec. 5	2-50	Nov. 1940	103	16.5	19.4	64.1

* One larva dead deep in apple plug. Percent survival 16.5, stung 16.5 dead 67.0 with only 66.0 of clean fruit.

**One larva dead deep in apple plug. Percent survival 69.9, stung 2.9, dead 27.2 with only 26.2 of clean fruit.

Table 1.--Results of laboratory tests against codling (cont.) moth larvae of various samples obtained from the roots of Thunder God Vine (Lei Kung t'eng) Tripterygium wilfordii. Local larvae.

Sample and dosage		Date of test	No. Plugs	Percentage		
				Wormy	Stung	Clean
557, Extractive of 107	1-50	May 1940	95	5.2	9.5	85.3
558, Extractive of 107	1½-50	May 1940	95	3.1	7.4	89.5
560, Extractive	1-50	May 1940	105	27.6	12.4	60.0
561, Extractive	1-50	May 1940	100	11.0	6.0	83.0
566, Extractive	1-50	May 1940	36	100.0	0.0	0.0
567, Extractive	1-50	May 1940	107	43.0	0.9	56.1
568, Extractive	1-50	May 1940	104	8.7	6.7	84.6
569, Extractive	1-50	May 1940	102	27.4	10.8	61.8

Larval Baits as Surface-Feeding Stimulants

Further attempts to increase the effectiveness of lead arsenate, by combining with it larval attractants as a means of stimulating surface feeding, were carried out during the year. Winesap apple seeds, at the rate of 8 pounds to 50 gallons of a spray containing 2 pounds of lead arsenate, were macerated and extracted in the cold for 24 hours with ethanol. The results indicated that the addition of the apple seed extract was not helpful.

In another experiment, freshly prepared apple juice, made from the flesh of Winesap apples, was added at the rate of 8-50 to a lead arsenate spray of 2-50 dosage. The data showed that the effectiveness of lead arsenate was not increased through the addition of apple juice.

Further experiments were conducted in which an ethanolic extract of Winesap apple skins was used. The extractive was combined with lead arsenate (2-50). Two replicates of lead arsenate alone gave an average of 24 percent of survivals, whereas two of lead arsenate plus apple skin extract gave 13 percent. An analysis of variance indicated that the addition of the apple-skin extractive to lead arsenate was significantly helpful in killing the larvae. It would seem logical that the skins of apples might contain larval attractants.

In view of the indication that the addition of an alcohol extract of apple skins to lead arsenate increases the effectiveness of the latter, cooperative work has been arranged with the Division of Insecticide Investigations to further study the possible attractiveness of various constituents of the apple to codling moth larvae. The primary object of this work is to stimulate larval feeding on the poisoned surfaces of both apple foliage and fruit. If a considerable percentage of the larvae could be induced to ingest a lethal dose of the poisoned foliage before reaching the fruit, much better control of the codling moth would likely be effected.

Aluminum hydroxide, a Potential Sticker for Phenothiazine

In the studies on aluminum hydroxide as a sticker for phenothiazine which were conducted during July and August, Madame Butterfly rose and Delicious apple foliage were compared directly. The sprays were applied by means of a compressed-air sprayer to potted plants as they revolved on a turntable. The plants were wetted with the maximum quantity of spray which could be made to adhere to the upper and lower surfaces of the leaves. After an interval of a day, the plants were washed with 1 pint of water with the same apparatus. A number of replicated samples of 200 disks each of apple and rose foliage were taken from which Dr. Cupples, of the Division of Insecticide Investigations, used 50 for each analysis. The sticker employed in these tests was tank made in accordance with a formula developed by Dr. Cupples. Unfortunately, the results of the tests made at this laboratory were quite irregular, and for this reason no reliable conclusions could be drawn as to the value of aluminum hydroxide as a sticker for phenothiazine. Experiments by Dr. Cupples, however, show it to be effective.

Studies were subsequently made to determine what effect the aluminum hydroxide might have on the toxicity of phenothiazine. Two physical forms of phenothiazine, regular and micronized, were employed, and the tests were replicated three times. The data obtained showed that phenothiazine, regular, permitted 21.7 percent of survivals, whereas the compound when mixed with aluminum hydroxide allowed 41.3 percent of living larvae. In the case of the micronized phenothiazine, the percentage of survivals was about doubled through the addition of aluminum hydroxide. Incidentally, it was of importance to note that the micronized phenothiazine was much more effective than the regular grade. In connection with these studies, it should not be inferred that aluminum hydroxide is without possible value as a sticker because of its effect on the toxicity of phenothiazine. It will be necessary to make further toxicological studies to determine the effectiveness of the phenothiazine-aluminum hydroxide combination after washing in comparison with phenothiazine alone following washing.

Weathering Tests of Chemically-treated Bands

Corrugated paper bands, chemically-treated in accordance with the formulas given in Table 2 were attached to uniform wooden posts and exposed thereon to the weather from July 1 to November 4, 1940. During this period there were 13.35 inches of rain. The summarized data with respect to the average percent of chemical load lost are also given in Table 2. These results are based on the weights of 80 bands before and after exposure. As will be noted, the cold-dipped bands lost the least of the chemical coating (49.8%) and the hot-dipped bands (100 viscosity oil) lost the most (69.8%).

Table 2.--Loss of chemical loads from chemically-treated bands applied to posts. Beltsville, Maryland. 1940

Formula	No. of bands	Average percent of chemical load lost
Formula No. 1 (Hot dipped) Beta Naphthol (tech'l.) - 1 lb. Oil (lubricating) 300 S.U.V. - 1 1/2 pts.	5 5 5	A - 50.5 B - 59.2 C - 62.5 Mean 57.4
Formula No. 9 (Hot dipped) Beta naphthol (tech'l.) - 1 lb. Oil (lubricating) 100 S.U.V. - 1 1/2 pts. Aluminum stearate - 0.5 oz.	5 10 5	A - 57.89 B - 64.30 C - 67.95 Mean 63.4
Formula No. 17 (Hot dipped) Beta naphthol (tech'l.) - 1 lb. Oil (lubricating) 100 S.U.V. - 1 1/2 pts.	5 10 5 5	A - 70.00 B - 71.25 C - 74.75 D - 63.06 Mean 69.8
Formula No. 14 (Cold dipped) Beta naphthol (tech'l.) - 1 lb. Oil (lubricating) 100 S.U.V. - 1 1/2 pts. Diluted with gasoline	5 10 5	A - 44.84 B - 50.80 C - 53.87 Mean 49.8

A = Original chemical load of about 0.30 ounces per foot of band.
B = Original chemical load of about 0.40 ounces per foot of band.
C = Original chemical load of about 0.50 ounces per foot of band.
D = Original chemical load of about 0.75 ounces per foot of band.

Of the four formulas used, an analysis of variance indicates that the differences between bands were highly significant except in the case of the cold-dipped formula with which a negative "F" value was obtained. An analysis of the variance of the four formulas used in 1940 also shows that there is high significance between formulas.

In Table 3 will be found a summary covering a period of four successive years during which four formulas and three to four chemical loads of each were tested to determine the extent of weathering of the chemically-treated bands. In accordance with these data, Formula 1 - hot dip - (beta naphthol, tech'l., 1 pound; oil (lubricating) 300 S.U.V., 1 1/2 pints) and Formula 14 - cold dip - (beta naphthol, tech'l., 1 pound; oil (lubricating)100 S.U.V., 1 1/2 pints; diluted with gasoline) were the most resistant to weathering, the average losses being 54.3 and 54.6 percents respectively. The other two formulas weathered almost as well, namely, Formula 9 - hot dip - (beta naphthol, tech'l., 1 pound; oil (lubricating) 100 S.U.V., 1 1/2 pints; aluminum stearate 0.5 ounce) had a loss of 58.7 percent and Formula 17 - hot dip - (beta naphthol tech'l., 1 pound; oil (lubricating) 100 S.U.V., 1 1/2 pints) a loss of 63.9 percent. An analysis of variance of the results obtained with the four formulas which have been tested in four successive years has been made. By using the interaction variance for the calculation of "F" there is significance between formulas at the 5% level but not at the 1% level. There is no significant difference between Formulas 1 and 14 as is obvious from the untreated data and differences between Formulas 1 and 9 or between 14 and 9 do not reach those required for 100 to 1 odds. The differences between Formula 17 and any other formula exceeds the 1% level of significance.

Table 3.--Percent of chemical load lost by bands in tests conducted at Beltsville, Maryland, for four successive years.

Formula	Chemical load before exposure	Percent of chemical load lost				
		1937	1938	1939	1940	Average of 4 years
1	A	49.2	54.5	48.1	50.5	
	B	57.6	46.7	53.6	59.2	
	C	55.2	58.0	56.2	62.5	
	Mean	54.0	53.0	52.6	57.4	54.3
9	A	42.5	51.2	63.2	57.9	
	B	53.2	56.0	67.1	64.3	
	C	54.8	61.6	64.6	67.9	
	Mean	50.2	56.3	64.9	63.4	58.7
17	A	53.3	62.2	59.0	70.0	
	B	59.5	68.1	64.7	71.2	
	C	63.3	68.5	67.3	74.8	
	D	56.5	62.2	58.4	63.1	
	Mean	58.2	65.2	62.4	69.8	63.9
14	A	50.8	52.5	61.7	44.8	
	B	64.1	57.1	57.8	50.8	
	C	59.2	44.6	57.8	53.9	
	Mean	58.0	51.4	59.1	49.8	54.6

A = Original chemical load of about 0.30 ounces per foot of band.
B = Original chemical load of about 0.40 ounces per foot of band.
C = Original chemical load of about 0.50 ounces per foot of band.
D = Original chemical load of about 0.75 ounces per foot of band.

ST. JOSEPH, MISSOURI

Howard Baker, In Charge

Seasonal Conditions

Rainfall was greater and more nearly normal than in any year since 1934. It was, however, much above normal in August and much below normal in September and October.

The crop of the summer and Jonathan varieties was spotted and much below normal while that of most varieties later than Jonathan was near or above normal for the section as a whole. The crop, as a whole, was one of the largest and best "off-year" ones ever produced in this area. Preharvest dropping of worm-free, maturing fruit on trees whose foliage was in fair to good condition was unusually light and much less than in most other recent years.

Abnormally low temperatures that prevailed during the period November 11 to 15, inclusive, appear to have injured trees of the Jonathan and later maturing varieties severely throughout this region.

Despite the fact that mortality of hibernating codling moth larvae, due to the abnormally low temperatures that prevailed during January 1940, ranged from 35 to 40 percent in most hill-land orchards to from 60 to 75 percent in bottom-land ones, the surviving population was much larger than normal. As a result, the ten bait traps operated in and adjoining the experimental spray block caught an average of 846 moths each during the season. This is considerably less than the number of moths caught per trap in 1939 but moderately to considerable higher than the number caught in any other previous season.

Bait trap catches of spring-brood moths began May 13, or about a week later than normal, reached their peak June 2, and were large during the period May 27 to June 6. Bait trap catches of first-brood moths began about July 15, reached their peak August 2, and were high during the period July 25 to August 8. Moths were caught in moderate to large numbers from August 8 until September 22 when rain did not interfere with their activity.

Egg laying by spring-brood moths began during the period May 21 to 25, reached its peak June 6 to 10, and continued at a moderate level until June 21 to 25. Egg laying by moths of the later broods began during the latter part of the first half of July, reached a moderate level by July 18, continued at a moderate to high level during the period July 18 to September 6, and reached its peak during the period August 28 to 31, inclusive.

Worm injury was generally much less than in 1939 and ranged from very light to light in most of the well-sprayed younger orchards to moderate or slightly heavier in the older, more heavily infested orchards. The third brood of worms was considerably smaller than in the last two or three years.

Field Tests of Insecticides

Tests of miscellaneous treatments

Small plot field spray tests of insecticides for control of the codling moth were carried out in a block of trees of the Jonathan variety located near Troy, Kansas. The trees were 23 years old, rather thick and bushy, and had a light to moderate spotted crop. All treatments were applied to single trees replicated nine times. The codling moth infestation was heavy as indicated by the fact that the bait traps operated caught an average of 846 moths each.

The entire block was given a prebloom scab spray of liquid lime sulphur April 24 and a uniform calyx spray of lead arsenate, hydrated lime, and dry lime sulphur May 13. The experimental treatments were applied in seven cover sprays as follows: 1st cover - May 27, 28; 2nd cover - June 5; 3rd cover - June 17; 4th cover - July 9, 10; 5th cover - July 19, 20; 6th cover - August 2, 3; and 7th cover - August 19, 20. Harvest was started September 16 and completed September 28.

The treatments tested and the results effected by them are given in table 1.

Table 1. Results of small plot field experiments for codling moth control, St. Joseph, Mo., 1940.

Plat No.	Treatment* (Quantities for 100 gallons unless otherwise stated)	Apples per tree	Percent clean	Total per 100 apples Worms**	Stings
2.	Lead arsenate + hydrated lime or Bordeaux mixture as in Plat 1 + mineral (summer) oil 3 qts. in 3rd cover.	1823	61.5	29.3	33.4
1.	Lead arsenate 3 lbs. + hydrated lime 3 lbs. in 1st cover; lead arsenate 4 lbs. + hydrated lime 4 lbs. in 2nd cover; lead arsenate 4 lbs. + Bordeaux mixture $\frac{3}{4}$-$1\frac{1}{2}$-100 in 3rd cover; lead arsenate 3 lbs. + Bordeaux mixture $\frac{3}{4}$-$1\frac{1}{2}$-100 in 4th to 7th covers incl.	1120	52.9	34.4	43.5
4.	Tank-mix nicotine bentonite; nicotine sulfate (40% nicotine) 1 pt. + bentonite 5 lbs. + soybean oil 1 qt. in first 4 covers except soybean oil omitted from 1st cover; same material except nicotine and bentonite reduced one-half in 5th, 6th, and 7th covers.	1278	65.3	36.0	9.8
8.	Tank-mix nicotine bentonite as in Plat 4 in first 4 covers; processed nicotine bentonite (4.74% nicotine) 6 lbs. + mineral oil 2 qts. in 5th, 6th, and 7th covers.	1525	60.8	42.3	11.9
5.	Tank-mix nicotine bentonite as in Plat 4 in first 4 covers; nicotine sulfate (40% nicotine) 2/3 pt. + mineral oil 2 qts. + bentonite 1 lb. in 5th, 6th, and 7th covers.	1677	57.1	45.2	12.4
3.	Lead arsenate + hydrated lime or Bordeaux mixture as in Plat 1 + soybean flour $\frac{1}{4}$ lb.	1386	50.1	45.9	45.6
6.	Tank-mix nicotine bentonite as in Plat 4 in first 4 covers; dry-mix nicotine bentonite (7.60% nicotine) 4.16 lbs. + mineral oil 2 qts. in 5th, 6th, and 7th covers.	1294	57.8	47.4	8.1
7.	Tank-mix nicotine bentonite as in Plat 4 in first 4 covers; processed nicotine bentonite (4.74% nicotine) 4 lbs. + mineral oil 2 qts. in 5th, 6th, and 7th covers.	1173	56.2	52.2	9.6
9.	Xanthone 2 lbs. + sodium oleate soap 1 lb. + zinc sulfate 4.5 oz. in 1st, 2nd, and 3rd covers; xanthone 2 lbs. + sodium oleate soap 1-2/3 lbs. + zinc sulfate 4.5 oz. in 4th to 7th covers, incl.	1606	32.6	91.0	22.7
10.	Xanthone $1\frac{1}{2}$ lbs. + sodium oleate soap 1 lb. + zinc sulfate 4.5 oz. in 1st cover; xanthone 2 lbs. + varying amounts of type III rosin residue emulsified with casein-ammonia in 2nd to 7th cover, incl.	1083	24.8	113.6	30.2

* - Wettable sulphur, 5 lbs., was used with all treatments in the 1st cover for scab control.

** - Difference in total worms per 100 apples required for significance (Analyses of variance): P = .05 15.6; P = .01 20.8

Large scale comparison of lead arsenate and nicotine

A standard lead arsenate and a modified tank-mix nicotine bentonite treatment were compared for their ability to control codling moth in a block containing about 225 trees of the Jonathan, Delicious, and Winesap varieties in an orchard near Troy, Kansas. Most of the trees were in fair to good vigor and needed considerable pruning. The Jonathan trees had a light, spotted crop and the Delicious and Winesap trees a heavy one. The codling moth infestation was very heavy in the area containing and surrounding the Jonathan trees and much lighter in the area containing and surrounding the Delicious and Winesap trees. Each treatment was replicated 8 times in the experimental block with 2 replications in the Jonathan area, 2 in the Delicious, and 4 in the Winesap one. Each replication was 2 tree rows wide by 7 or 8 trees long. Location of the treatments within varieties was determined by chance.

The entire block was given a prebloom scab spray of liquid lime sulphur April 24, 25 and a uniform calyx spray of lead arsenate, hydrated lime, and dry lime sulphur May 14. The experimental treatments were applied in seven cover sprays as follows: 1st cover - May 28; 2nd cover - June 6,7; 3rd cover - June 18; 4th cover - July 10; 5th cover - July 22; 6th cover - August 3,5; and 7th cover - August 20,21. In addition, one row, selected by chance, in each replication of each treatment was given an 8th cover spray September 6.

The treatments tested were as follows: (Amounts per 100 gallons)

(1) Lead arsenate 3 lbs. + hydrated line 3 lbs. + wettable sulphur 5 lbs. in 1st cover; lead arsenate 4 lbs. + hydrated lime 4 lbs. in 2nd cover; lead arsenate 4 lbs. + mineral (summer) oil 3 qts. + Bordeaux mixture 3/4-1-1/2-100 in 3rd cover; lead arsenate 3 lbs. + Bordeaux mixture 3/4-1-1/2-100 in 4th, 5th, 6th, 7th, and 8th covers.

(2) Tank-mix nicotine bentonite; nicotine sulfate (40% nicotine) 1 pt. + bentonite 5 lbs. + wettable sulphur 5 lbs. in 1st cover; nicotine sulfate 1 pt. + bentonite 5 lbs. + soybean oil 1 qt. in 2nd, 3rd, and 4th covers; nicotine sulfate 2/3 pt. + bentonite 1 lb. + mineral (summer) oil 2 qts. in 5th, 6th, and 7th covers, nicotine sulfate 2/3 pt. + mineral (summer) oil 2 qts. in 8th cover.

A summary of the results effected by the two treatments is given in table 2 which follows. These results are based on all drop and harvested fruit from 4 trees in each replication of each treatment, half of which received 7 and half 8 cover sprays.

Table 2. Results of large plot field spray experiment for codling moth control, St. Joseph, Mo., 1940.

Treatment	Number of trees	Apples per tree	Percent clean	Total per 100 apples Worms	Stings
		Variety - Jonathan			
Lead arsenate	8	2811	64.2	25.4	26.9
Nicotine	8	1888	58.2	41.9	12.5
		Variety - Delicious			
Lead arsenate	8	3179	84.7	5.6	14.0
Nicotine	8	2766	86.6	9.7	4.6
		Variety - Winesap			
Lead arsenate	16	4004	87.2	3.7	11.4
Nicotine	16	3608	86.1	8.0	6.8
		Variety - All combined			
Lead arsenate	32	3500	80.8	9.6 *	15.9
Nicotine	32	2967	79.3	16.9	7.7

* - By analysis of variance, the difference in total worms per 100 apples between the two treatments (all varieties combined) was significant, indicating the superiority of the lead arsenate treatment to the nicotine one.

The value of the extra cover spray applied to half of the large lead arsenate - nicotine block September 6 was determined by comparison of the degree of control found to obtain in the fruit harvested from the 7- as compared to that from the 8-cover spray area. The results are summarized in table 3 which follows.

Table 3. Control of codling moth with seven versus eight cover sprays in large plot field spray block, St. Joseph, Mo., 1940.

Treatment	Number of covers	Variety	Number of trees	Total apples	Percent clean	Total per 100 apples Worms	Stings
Lead arsenate	7	Jonathan	4	13,070	71.4	14.4	28.2
" "	8	"	4	6,003	65.7	21.0	29.8
Nicotine	7	"	4	4,958	61.8	38.7	12.2
"	8	"	4	6,356	67.5	28.9	13.3
Lead arsenate	7	Delicious	4	11,846	86.5	3.9	12.7
" "	8	"	4	9,992	85.1	3.6	17.4
Nicotine	7	"	4	8,369	86.5	8.3	5.6
"	8	"	4	10,385	92.9	4.0	3.7
Lead arsenate	7	Winesap	7	26,230	89.9	2.4	9.1
" "	8	"	9	35,301	87.0	2.6	13.1
Nicotine	7	"	9	29,428	88.3	6.1	6.4
"	8	"	7	25,462	88.2	5.1	7.2
Lead arsenate	7	All var.	15	51,136	84.4	5.8	14.8
" "	8	" "	17	51,296	84.1	4.9	15.9
Nicotine	7	" "	17	42,755	84.8	10.3	6.9
"	8	" "	15	42,203	86.2	8.4	7.2

Spray deposits

Analyses of the spray deposits on stratified samples of fruit taken from the several plats in both the small and large plot field spray blocks after each cover spray and at harvest beginning with after the first cover spray were made by Mr. Jack Fahey of the Division of Insecticide Investigations, Vincennes, Ind. laboratory. In general, there was a greater difference in the degree of control effected by the several treatments than the differences in the size of the deposits that were built and maintained would have indicated.

Injury to fruit and foliage

Lead arsenate as used with hydrated lime or Bordeaux mixture caused no injury worth noting to fruit or foliage in either the small or large plot field spray blocks, although a small number of yellow leaves did appear on Jonathan trees sprayed with this material. In some grower sprayed orchards, however, heavy lead arsenate programs used without a safener, such as hydrated lime, zinc sulfate, or Bordeaux mixture, caused moderate to severe injury to foliage and some injury to fruit.

None of the nicotine combinations caused any visible injury to fruit of the Jonathan variety in either block but the nicotine program used in the large plot experimental block affected the color and finish of fruit of the Delicious and Winesap varieties adversely. This injury was no greater where eight than where seven cover sprays were applied but was greater on the south and southwest than on other sides of the trees. The injury appeared due largely to the fact that too much mineral oil was used in the spray program and partly to the fact that comparatively warm, dry weather prevailed during most of the period when these varieties were maturing.

All of the nicotine combinations caused light to moderate injury to foliage of the Jonathan variety but the nicotine program used in the large plot experimental block did not injure foliage of the Delicious or Winesap varieties. The injury appeared in the form of yellow leaves, was light to moderate in amount, and not serious in any instance. This injury was first observed in any amount between the time of application of the 5th and 6th cover sprays, large as well as small leaves were affected, and it was greater in amount in those plats in which mineral oil was used for the first time in the 5th cover spray than in plat 4, in which soybean oil was still used. All evidence indicated that the injury was due largely to the oil. Later, about the time of the last spray application on August 19, yellow leaves appeared again in moderate numbers on trees in plats 4 and 8 and in small or very small numbers in other nicotine plats. This time the injury was confined to the smaller leaves.

Fruit and foliage on trees sprayed with xanthone developed an unnatural green color which was less intense than but characteristic of that which has occurred on fruit and foliage sprayed with phenothiazine in other years. Xanthone also russeted fruit to a moderate degree, especially about the calyx end, but caused no visible injury of importance to foliage. However, a small number of leaves on trees sprayed with xanthone developed small spots resembling copper injury along the mid rib.

Size of fruit, measured by the number of apples per bushel, did not appear to be affected by any of the spray treatments used.

Harvest residues

Analyses made by Mr. Fahey of the Vincennes, Ind. laboratory indicated that lead arsenate residues were removed to well below present tolerances for lead and arsenic on samples from all lead arsenate plats when they were washed in an unheated acid wash solution in an efficient flood-type washer. At the same time, additional analyses showed that lead residues exceeded the present tolerance of 0.05 grains of lead per pound of fruit by from two to nearly three times on samples wiped in a modern brush wiper. It is evident that the increase in the tolerances for lead and arsenic has not eliminated the necessity for washing when the spray program involves the use of lead arsenate throughout the season but it has made it easier to meet them by washing. The margin between the tolerance for lead and the lead residue that remained on our samples after washing indicates that moderately heavier programs of lead arsenate than those tested can be used without making it unduly difficult to meet that tolerance by washing in an unheated acid wash solution.

Since there is no tolerance for nicotine, nicotine residues are important only to the extent that they affect the appearance of the fruit when it is marketed. The harvest residue was heavy and unsightly on fruit from plat 4 and was much lighter but plainly visible, about equal in amount, and not seriously objectionable on fruit from all other nicotine plats. However, there was enough visible residue on fruit from all nicotine plats to require wiping. Dry brush wiping did not remove the residue from the stem end of the fruit satisfactorily in any instance and did not remove it as well from samples from plat 4 as from samples from other nicotine plats. In all cases, however, sufficient residue remained on the fruit after dry brush wiping to affect its appearance. In most cases, the residue that remained was in the form of what might be described as a "bentonite bloom" which might be overlooked by an ordinary, but not by a discriminating, buyer. The "bentonite bloom" was still evident but much less noticeable and did not detract appreciably from the appearance of wiped Jonathan and Delicious apples after they had been held in cold storage for two months. The residue on a sample of unwiped Jonathans from plat 5 of the small plot field spray block was still plainly visible after the fruit had been in cold storage for two months.

Control of codling moth by destruction of crop

The owner of a large, isolated, bottom-land orchard near Fortescue, Mo. destroyed his prospective 1939 crop almost completely on all but a small portion of his acreage by application of a bloom-killing spray. The primary purpose of this crop destruction was to starve out the codling moth and thereby reduce the population in the orchard to a low level. Despite the application of what should have been a satisfactory and effective lead arsenate spray program in 1938, the grower stated his 1938 crop was so wormy his best grade of packed fruit contained wormy apples. A few apples set on the trees in the area in which the 1939 bloom was destroyed but practically all became wormy and dropped from the trees by the middle of the summer. An excellent crop set on the trees in the small area in which the 1939 bloom was not destroyed. It was not sprayed during 1939 and became very wormy.

The entire orchard set and produced an excellent crop this year. It was well sprayed with lead arsenate throughout the season with one more cover spray being applied in the 1939 crop than in the 1939 no-crop area. At the end of the period of first-brood activity stratified samples of fruit on trees in the 1939 no-crop area were only 0.4 percent wormy while in the 1939 crop area they were 4.6 percent wormy. At the same time, the trees in the 1939 no-crop area had an average of only 1.6 wormy apples each on the ground while those in the 1939 crop area had 40.9 wormy apples each.

Control at the end of the season is given in table 4 and indicates that this grower's experiment was a decided success. The data given in table 4 were obtained by the examination of stratified samples of fruit just before harvest on 5 trees in each area. Drop fruit had not been removed from the orchard and was examined at the same time.

Table 4. Control of codling moth following destruction of previous season's prospective crop, Fortescue, Mo., 1940.

Treatment in 1939	Distance from 1939 crop area	Apples on trees			Apples on ground	
		Percent clean	Total per 100 apples Worms	Stings	No. wormy per tree	No. worms per tree
Crop	---	47.5	40.5	59.9	348.0	586.8
No crop	1 to 4 rows	84.8	8.0	14.3	95.6	116.8
No crop	9 to 15 rows	93.9	2.6	5.7	19.0	20.6

Miscellaneous Studies

Tests of the ability of nicotine to kill liberated, marked moths

A limited series of tests of the ability of 1 pint of nicotine sulfate (40% nicotine) per 100 gallons of lead arsenate plus fungicide or hydrated lime to kill liberated, marked moths was made. In tests conducted by Mr. Butler in late May and early June recoveries of liberated, marked larvae ranged from 12.5 percent on large 27-year old trees when it was quite windy to 35.0 percent when there was no wind. In these tests one man used a broom-type of gun from a tower and one man used a similar gun from the ground. Additional tests were made during the latter part of August with the following results as indicated in table 5.

Table 5. Recovery of liberated, marked moths using nicotine sulfate (40% nicotine) 1 pint per 100 gallons of lead arsenate-hydrated lime spray, St. Joseph, Mo., 1940

Date	Temp. °F.	Wind Estimated	Trees Number	Moths liberated* Number	Method of spraying**	Moths recovered*** Native Number	Liberated Number	Liberated Percent
8/22	76-80	Little	2	30	1	16	12	40.00
"	"	"	2	34	2	31	15	44.12
8/30	74-82	Strong	4	76	1	32	22	28.95
"	74.78	"	2	39	2	12	9	23.08
"	78-83	"	2	38	3	25	14	36.84

* - Moths that were inactive or injured at time of liberation were destroyed and not included in this figure. Liberated moths observed to fly from the trees before coming to rest were, also, not included in this figure.

** - (1) Two men per tree spraying from ground with single-nozzle guns; top and outside of tree sprayed first with men on opposite sides of tree.
(2) Same as (1) except 1 man in tower and 1 man on ground.
(3) One man per tree on ground with single-nozzle gun; center of tree sprayed first, then outside.

*** - Canvas on which moths collected spread to cover half of ground area beneath trees.

When it is considered that the canvas sheets on which the moths were collected covered only half of the ground area beneath the experimental trees it can be concluded that well over half of the liberated moths were killed by the spray applied. Very few of the captured moths effected a complete recovery. The limited data in the above table indicate that nicotine is able to kill a sizable portion of a moth population, that it is more effective when there is little or no wind than when there is more, and that the manner of application may not be especially important so long as it is thorough.

Survival of mature codling moth larvae and effect of scraping and banding on same

The studies of the proportion of the mature larvae that survive after leaving the fruit, reported on previously, were continued during 1940. In corroboration of the results as reported in previous years, it was found (1) mortality of the codling moth is heavy between the time that it exits from the fruit as a mature larva and emerges as a moth, (2) scraping of trees reduced the percent of transforming larvae that developed into moths by 26.4 percent and the percent of non-transforming larvae that entered hibernation successfully by 53.9 percent, and (3) banding of scraped trees reduced the percent of transforming larvae that developed into moths by 46.1 percent and the percent of non-transforming larvae that entered hibernation successfully by 72.7 percent.

The relation between bait-trap catches and codling moth emergence and egg laying

A study of the relation between bait-trap catches and codling moth emergence and egg laying was started in 1939 and continued during 1940. As in 1939, there was a close correlation between the time that moths emerged and the time that eggs were deposited and between the number of moths that emerged and the number of eggs deposited except during the first half of August when egg laying was undoubtedly curtailed owing to the unfavorable weather for moth activity that prevailed during that period.

Bait traps began to catch moths as soon as they began to emerge in the spring and continued to catch them to the end of the season. Since moths were emerging in some numbers at nearly all times the data show that bait traps indicate when moths are present. Fluctuations in moth emergence were reflected in fluctuations in bait-trap catches, and peak catches coincided with or followed shortly after periods of peak emergence. However, since many moths live normally for 2 weeks or longer, one would expect bait-trap catches to hold to a high level for some time after periods of peak emergence. This was not the case and suggests the possibility that the baits in use may be more attractive to newly emerged than to older moths or that, in general, newly emerged moths may be more responsive to baits of any kind than older ones. Although fluctuations in moth emergence were followed by fluctuations in bait-trap catches the ratio of bait-trap catches to moth emergence varied widely during the season. In other words, there was no consistent relationship between the number of moths caught in bait traps and the number of moths emerging. The peak catch of spring-brood moths was approximately as high as that of other broods despite the fact that moths emerged in much greater numbers during July and August

than during May and June. The data indicate, therefore, that bait traps show when moths are present and when they increase and decrease in number, but they do not indicate accurately what number may be present.

Bait-trap catches indicated the beginning and peak of egg laying by spring-brood moths accurately. They were not so reliable in indicating the beginning and peak of egg laying by moths of the later broods but the discrepancy was not great and spray applications timed by the catches were completed before the eggs began to hatch where only a limited time was needed to make the applications. Bait-trap catches failed utterly to indicate the heavy deposition of eggs that occurred during the latter part of August. Also, bait-trap catches decreased at a more rapid rate than egg laying following periods of peak activity. This is perhaps a further indication that older moths may not be attracted to bait traps as readily as younger ones, even though they may continue to deposit eggs. The size of the bait-trap catches failed to indicate the number of eggs that were deposited to about the same extent that they failed to indicate the comparative size of the moth population present.